Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries

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Published in:
Lancet Oncology

DOI:
10.1016/S1470-2045(21)00493-9

Publication date:
2021

THE LANCET
Oncology

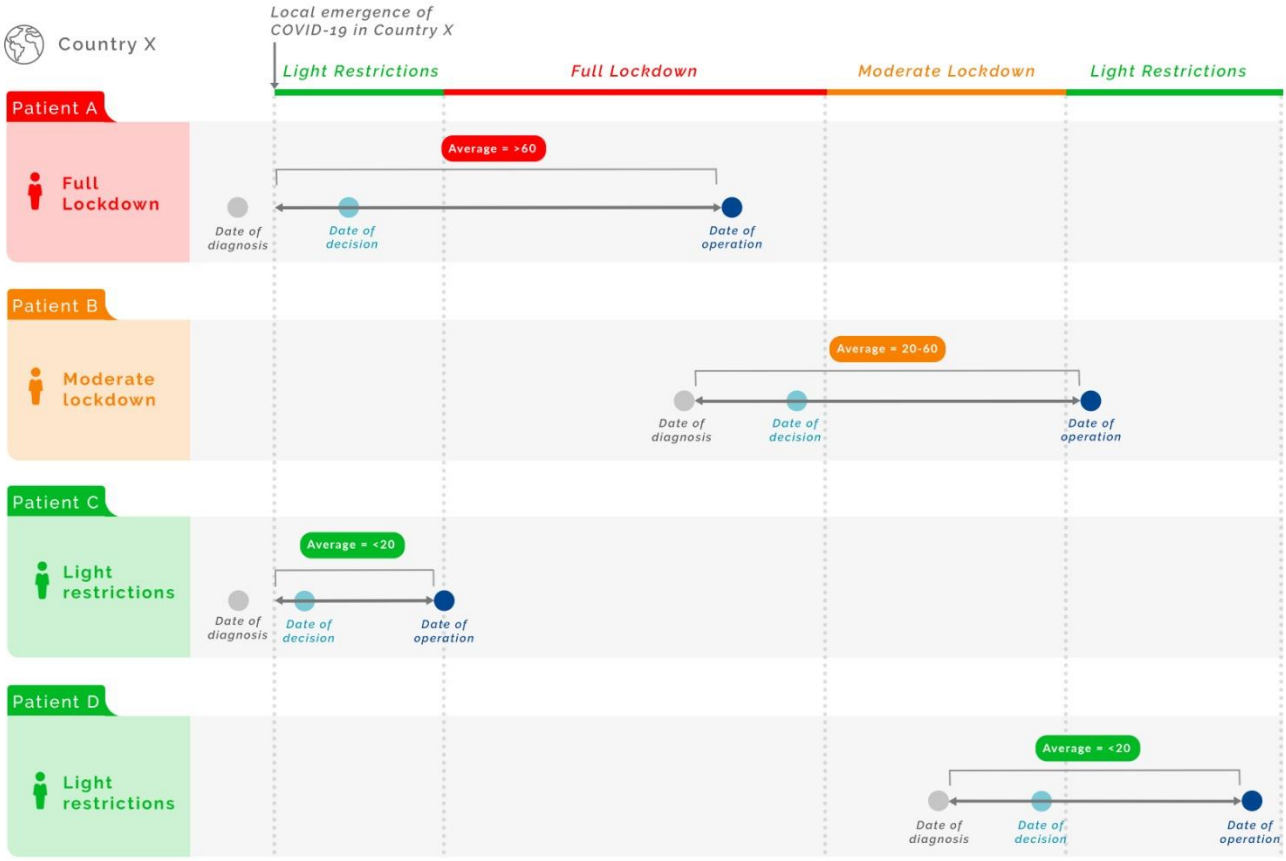
Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: COVIDSurg Collaborative. Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries: an international, prospective, cohort study. *Lancet Oncol* 2021; published online Oct 5. http://dx.doi.org/10.1016/S1470-2045(21)00493-9.

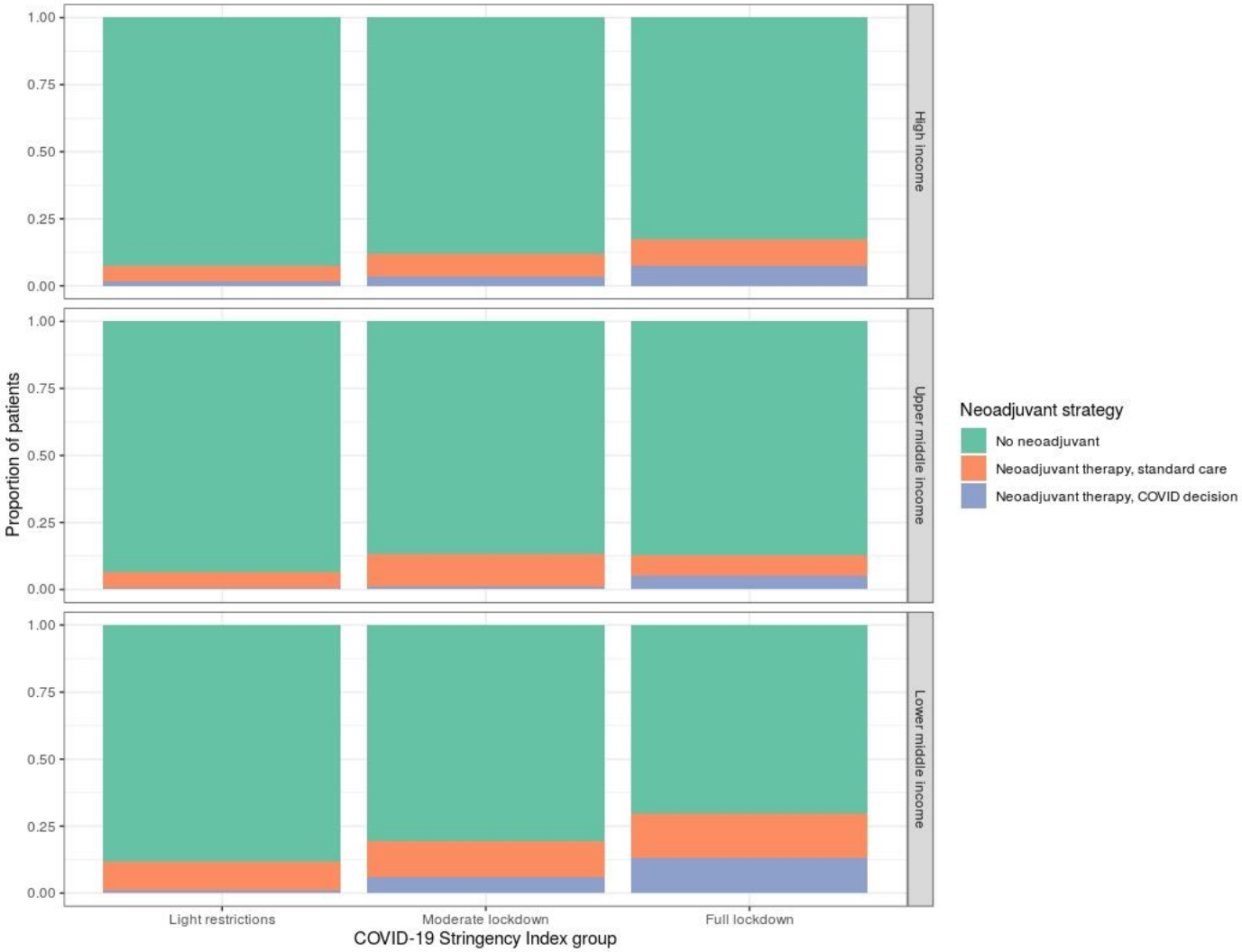
Web Appendix

Supplementary figure 1. COVID-19 government index response index classification.



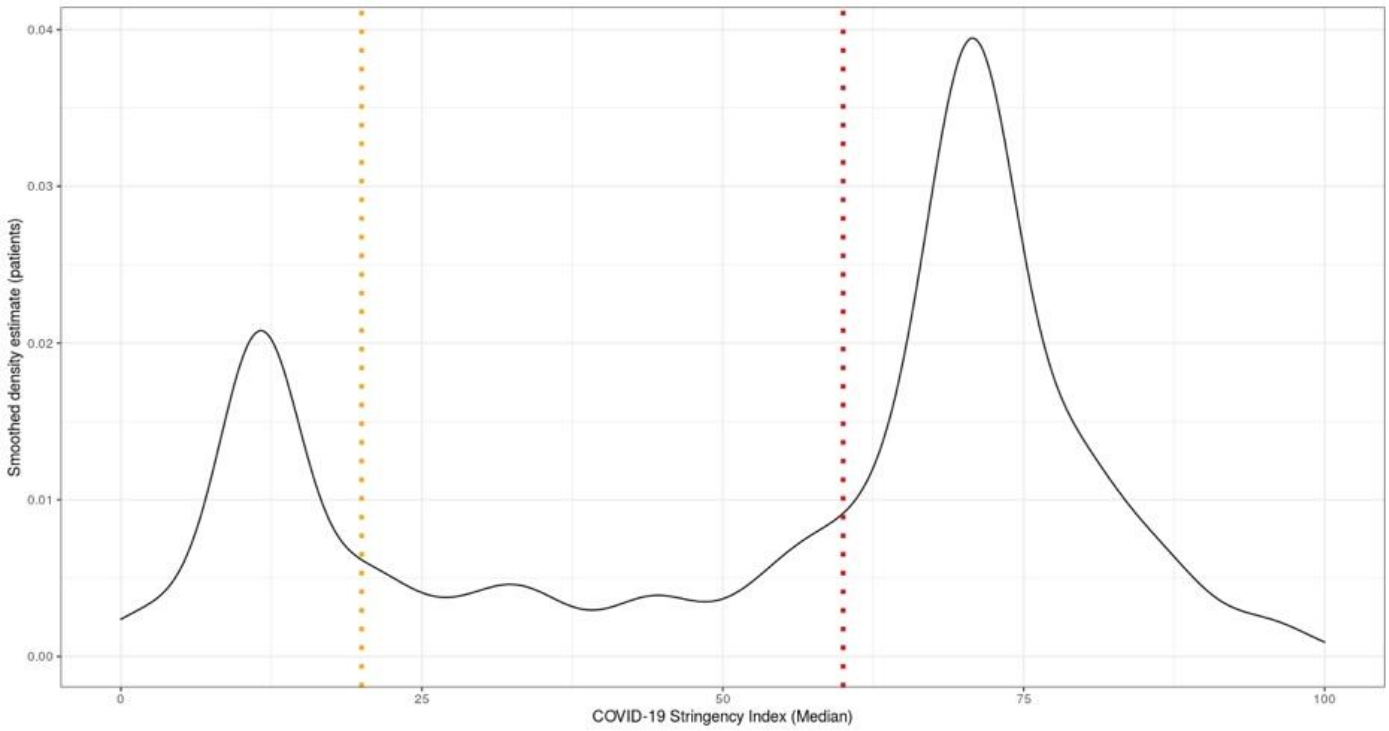
The median Oxford COVID-19 government response index score was calculated for each patient as a median average between local emergence of COVID-19 or data of diagnosis (whichever was latest) to the date of operation or cessation of follow-up if the patient remained non-operated. A representative example country is shown. The final classification is shown beneath each patient example.

Supplementary figure 2. Variation in use of neoadjuvant therapy across lockdowns across income groups



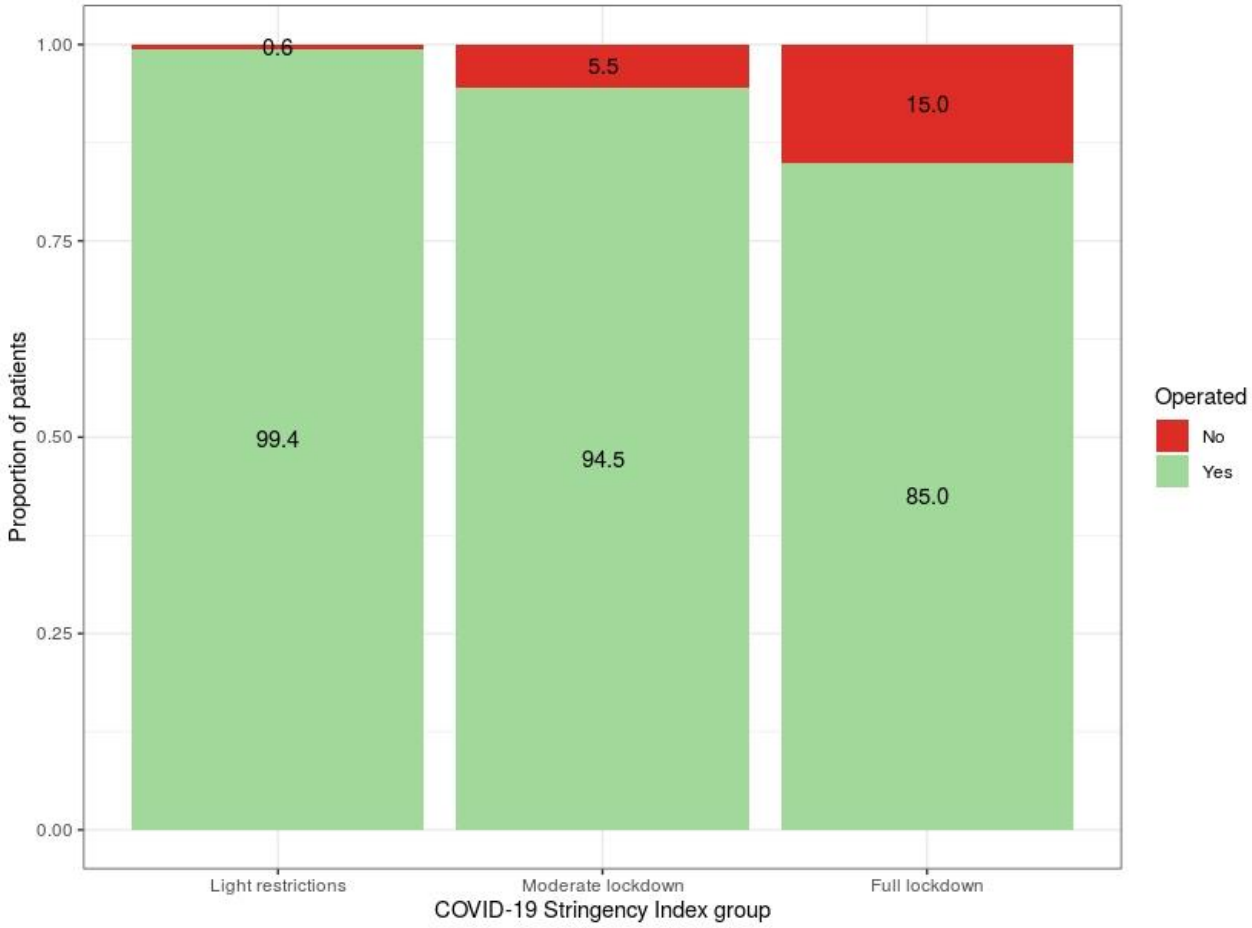
COVID=Coronavirus disease 2019.

Supplementary figure 3. Distribution of median COVID-19 Stringency Index scores



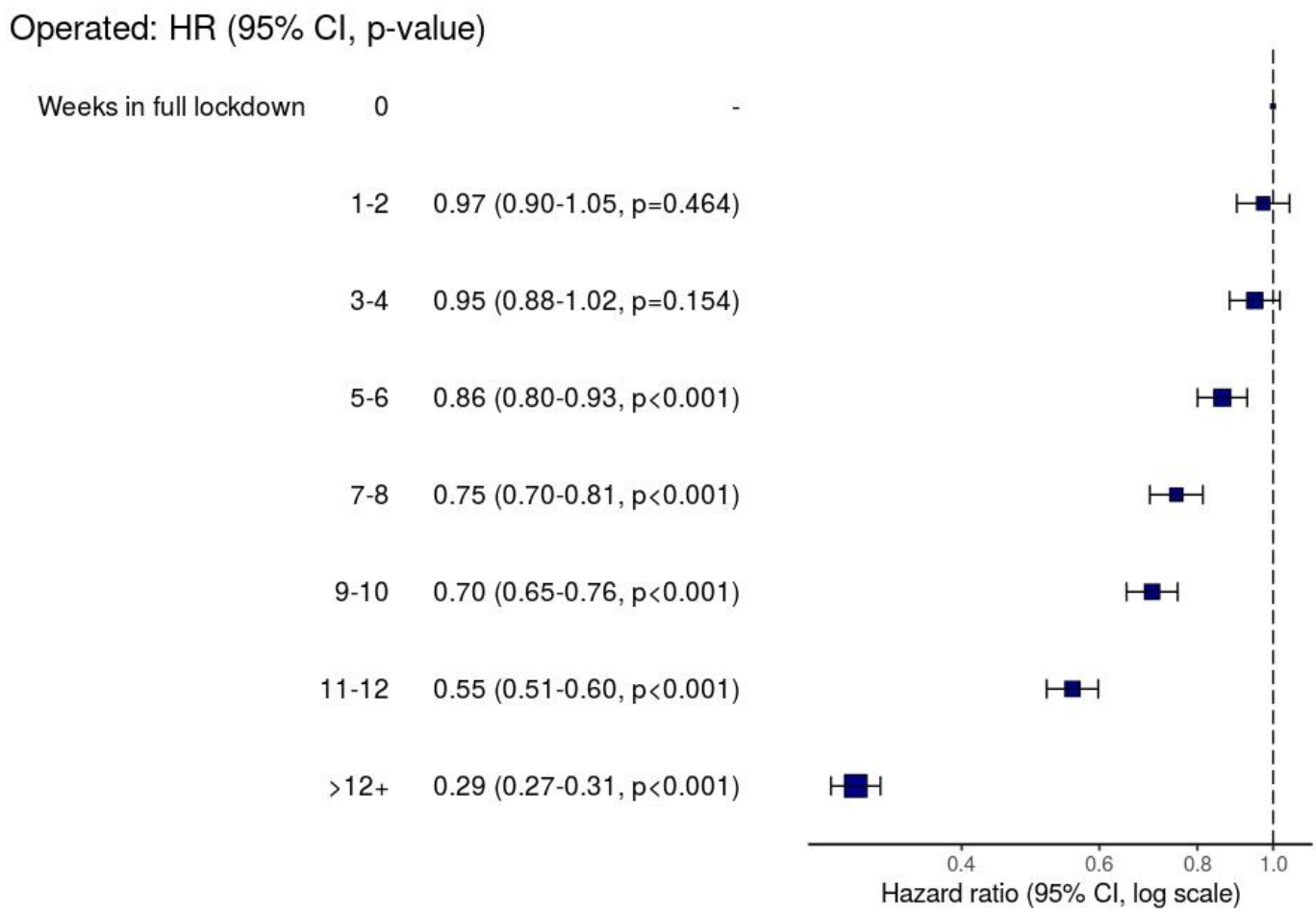
A median average COVID-19 stringency index score was calculated for each patient based on the date of first local COVID-19 cases up to the date of operation (operated patients) or cessation of follow-up (non-operated patients) in each included country (Supplementary figure 1). Patients were grouped based on their corresponding COVID-19 stringency index light restrictions (median index score <20 (orange)), moderate lockdown (median index score 20-60) and full lockdown (median index score >60 (red)).

Supplementary figure 4. Differences in overall surgical capacity during lockdowns



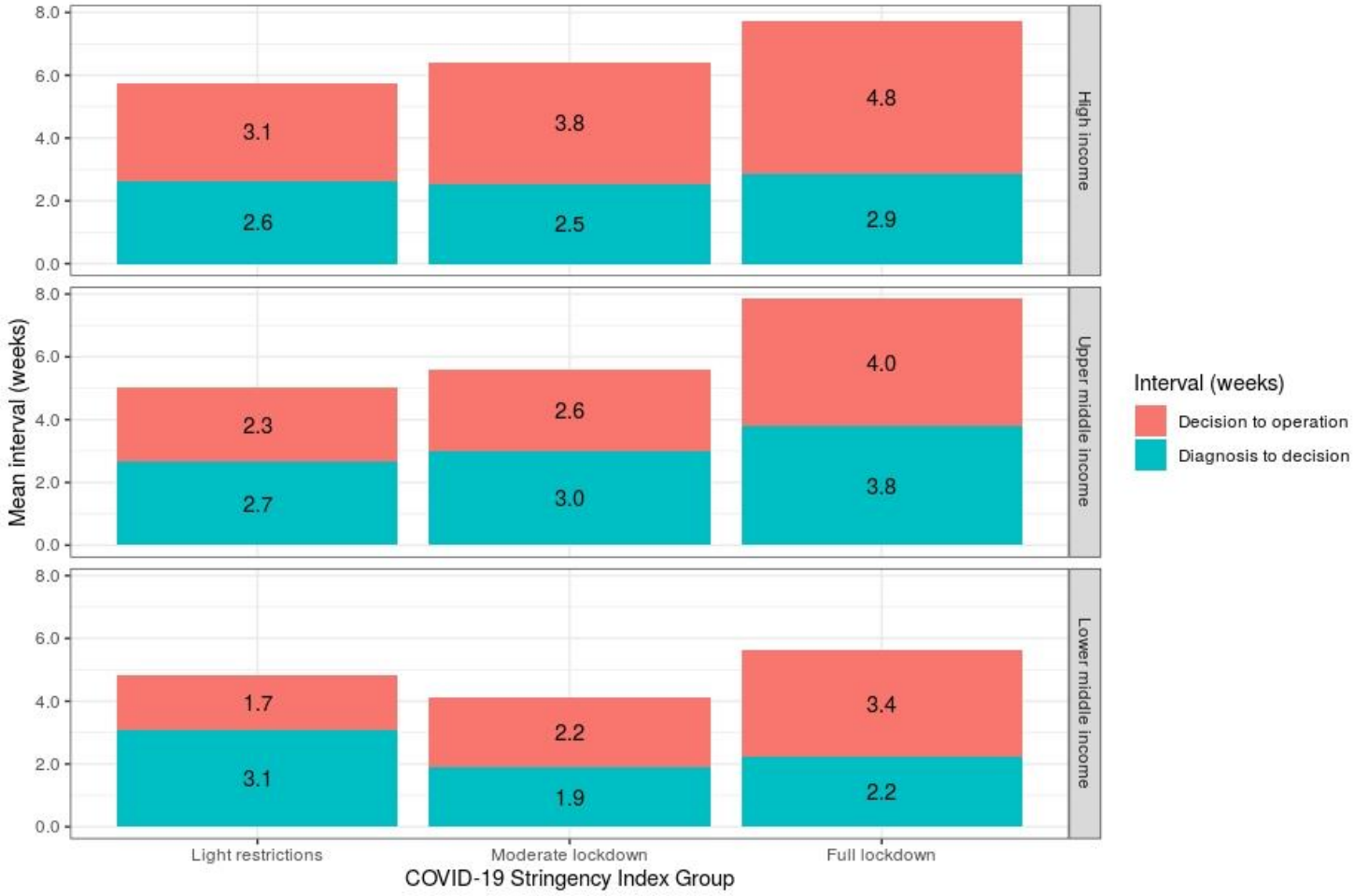
Percentages displayed represent proportion operated by group

Supplementary figure 5. Hazard ratio plot for secondary analysis of weeks in full lockdown



Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Full lockdown defined as full weeks with COVID-19 stringency index score ≥60. Upon testing for a non-linear relationship between weeks in full lockdown and the outcome variable using a penalised spline on the exposure, a significant non-linear relationship was demonstrated (p<0.001). This was confirmed graphically using a spline plot. Therefore, weeks in lockdown were grouped in 2-week increments for the purpose of modelling. The same covariables were included in this secondary analysis as the primary model.

Supplementary figure 6. Variability in system friction from diagnosis to decision for surgery to operation



Plot displays patients that went straight to surgery (no neoadjuvant therapy only). Mean interval by group displayed. The point of system 'friction' was different across income and lockdown groups. Lockdown typically increased the interval from decision to operation across all settings. The interval from diagnosis to decision was a higher contributor to overall delay in UMICs and LMICs than in HICs.

Supplementary table 1a. Cancer types across World Bank income groups

Cancer location	High income	Upper middle income	Lower middle income	Total
Head and neck	2480 (15.6)	448 (23.7)	589 (26.2)	3517 (17.6)
Colon	2955 (18.6)	287 (15.2)	186 (8.3)	3428 (17.1)
Rectal	1235 (7.8)	138 (7.3)	139 (6.2)	1512 (7.6)
Gastric	515 (3.2)	119 (6.3)	89 (4.0)	723 (3.6)
Oesophageal	391 (2.5)	23 (1.2)	37 (1.6)	451 (2.3)
Thoracic	1172 (7.4)	10 (0.5)	10 (0.4)	1192 (6.0)
Liver	649 (4.1)	38 (2.0)	88 (3.9)	775 (3.9)
Pancreatic	571 (3.6)	77 (4.1)	128 (5.7)	776 (3.9)
Sarcoma	353 (2.2)	17 (0.9)	68 (3.0)	438 (2.2)
Prostate	511 (3.2)	13 (0.7)	13 (0.6)	537 (2.7)
Kidney or upper tract urothelial	389 (2.5)	22 (1.2)	31 (1.4)	442 (2.2)
Bladder	108 (0.7)	5 (0.3)	34 (1.5)	147 (0.7)
Gynaecological	1776 (11.2)	236 (12.5)	157 (7.0)	2169 (10.8)
Breast	2758 (17.4)	458 (24.2)	680 (30.2)	3896 (19.5)
Intracranial*	653 (2.9)	110 (3.7)	120 (4.7)	883 (3.2)

Percentages expressed of column total. Country income defined in accordance with World Bank income (2019/20) classifications. Lower middle income included patients from both lower-middle income and low-income countries. *Surgical intent data was unavailable for intracranial tumours. Treatment pathways and outcomes related to delay were considered too disparate from other tumour types for combined analysis. Therefore, data for intracranial tumours was not included in further analyses in this paper, nor the summary flowchart in Figure 1.

Supplementary table 1b. Patients included by country and income group

High income			Upper middle income			Lower middle income		
Country	Patients	Centres	Country	Patients	Centres	Country	Patients	Centres
Australia	716 (4.5)	18	Argentina	71 (3.8)	2	Egypt	287 (12.8)	12
Austria	163 (1.0)	2	Azerbaijan	3 (0.2)	1	Ghana	14 (0.6)	1
Barbados	19 (0.1)	1	Botswana	9 (0.5)	1	India	1566 (69.6)	15
Belgium	25 (0.2)	3	Brazil	430 (22.7)	8	Indonesia	90 (4.0)	1
Canada	373 (2.4)	10	Colombia	138 (7.3)	5	Morocco	140 (6.2)	1
Chile	50 (0.3)	2	Guatemala	1 (0.1)	1	Nigeria	50 (2.2)	6
Croatia	19 (0.1)	1	Jordan	31 (1.6)	2	Pakistan	81 (3.6)	8
Czech Republic	3 (0.0)	1	Libya	66 (3.5)	3	Philippines	5 (0.2)	1
Denmark	174 (1.1)	2	Malaysia	194 (10.3)	7	Reunion	3 (0.1)	1
Finland	103 (0.6)	2	Mexico	128 (6.8)	1	Sudan	11 (0.5)	3
France	508 (3.2)	14	Peru	34 (1.8)	1	Syria	2 (0.1)	1
Germany	399 (2.5)	9	Romania	17 (0.9)	2	Uganda	1 (0.0)	1
Greece	266 (1.7)	11	Russia	4 (0.2)	1	Yemen	2 (0.1)	1
Hong Kong	62 (0.4)	3	Serbia	179 (9.5)	4			
Hungary	45 (0.3)	1	South Africa	92 (4.9)	1			
Ireland	177 (1.1)	8	Sri Lanka	19 (1.0)	1			
Italy	2291 (14.4)	47	Turkey	475 (25.1)	15			
Japan	19 (0.1)	1						
Kuwait	7 (0.0)	1						
Netherlands	234 (1.5)	7						
Oman	2 (0.0)	1						
Portugal	435 (2.7)	15						
Saudi Arabia	373 (2.4)	11						
Singapore	191 (1.2)	2						
Slovak Republic	3 (0.0)	1						
Slovenia	51 (0.3)	1						
Spain	1478 (9.3)	38						
Sweden	171 (1.1)	5						
Switzerland	127 (0.8)	5						
United Kingdom	6160 (38.8)	113						
United States	1219 (7.7)	21						

Percentages expressed of column total.

Supplementary table 2. Characteristics for patients awaiting surgery during light restrictions, moderate and full lockdowns

		COVID-19 Stringency Index group			
Factor	**Levels**	**Light restrictions**	**Moderate lockdown**	**Full lockdown**	**P-value**
Health system factors					
Weeks in full lockdown	Mean (SD)	2.4 (1.7)	5.5 (2.9)	12.7 (5.4)	<0.001
World Bank Income Classification	High income	4089 (90.4)	3130 (85.8)	8644 (73.1)	<0.001
	Upper middle income	228 (5.0)	325 (8.9)	1329 (11.2)	
	Lower middle income	204 (4.5)	191 (5.2)	1854 (15.7)	
Community SARS-CoV-2 case notification rate*	High income, low COVID	2952 (65.3)	1144 (31.4)	367 (3.1)	<0.001
	High income, high COVID	1137 (25.1)	1986 (54.5)	8277 (70.0)	
	Upper middle income, low COVID	228 (5.0)	248 (6.8)	262 (2.2)	
	Upper middle income, high COVID	0 (0.0)	77 (2.1)	1067 (9.0)	
	Lower middle income, low COVID	204 (4.5)	181 (5.0)	1205 (10.2)	
	Lower middle income, high COVID	0 (0.0)	10 (0.3)	649 (5.5)	
Patient factors					
Age	<50 years	775 (17.1)	562 (15.4)	2355 (19.9)	<0.001
	50-59 years	962 (21.3)	764 (21.0)	2409 (20.4)	
	60-69 years	1222 (27.0)	1048 (28.7)	3144 (26.6)	
	70-79 years	1176 (26.0)	927 (25.4)	2740 (23.2)	
	>80 years	386 (8.5)	345 (9.5)	1179 (10.0)	
Sex	Female	2711 (60.0)	2100 (57.6)	6666 (56.4)	<0.001
	Male	1810 (40.0)	1546 (42.4)	5161 (43.6)	
ASA grade	Grade 1-2	3274 (72.7)	2493 (68.6)	8381 (71.2)	<0.001
	Grade 3-5	1230 (27.3)	1143 (31.4)	3382 (28.8)	
	Missing	17	10	64	
ECOG performance score	0	2785 (63.0)	2157 (60.3)	6595 (56.7)	<0.001
	1	1186 (26.8)	1005 (28.1)	3645 (31.3)	
	≥2	448 (10.1)	417 (11.7)	1397 (12.0)	
	Missing	102	67	190	
Current smoker	No	4026 (89.1)	3202 (87.8)	10437 (88.2)	0.195
	Yes	495 (10.9)	444 (12.2)	1390 (11.8)	
Pre-existing respiratory condition	No	3950 (87.4)	3219 (88.3)	10571 (89.4)	0.001
	Yes	571 (12.6)	427 (11.7)	1256 (10.6)	
Revised Cardiac Risk Index	0	1355 (30.0)	1121 (30.7)	3603 (30.5)	0.032
	1	2331 (51.6)	1820 (49.9)	6092 (51.5)	
	2	691 (15.3)	541 (14.8)	1684 (14.2)	
	≥3	144 (3.2)	164 (4.5)	448 (3.8)	
Disease factors					
Disease stage	Early disease	2582 (57.4)	1960 (54.4)	6226 (54.2)	<0.001
	Advanced/nodal disease	1919 (42.6)	1641 (45.6)	5258 (45.8)	
	Missing	20	45	343	
Site specific cancer	Head and neck	672 (14.9)	649 (17.8)	2193 (18.5)	<0.001
	Colon	902 (20.0)	609 (16.7)	1913 (16.2)	
	Rectal	313 (6.9)	272 (7.5)	926 (7.8)	
	Gastric	83 (1.8)	148 (4.1)	492 (4.2)	
	Oesophageal	62 (1.4)	59 (1.6)	329 (2.8)	
	Thoracic	350 (7.7)	197 (5.4)	645 (5.5)	
	Liver	139 (3.1)	165 (4.5)	471 (4.0)	
	Pancreatic	138 (3.1)	145 (4.0)	493 (4.2)	
	Sarcoma	76 (1.7)	89 (2.4)	273 (2.3)	
	Prostate	123 (2.7)	61 (1.7)	353 (3.0)	
	Kidney or upper tract urothelial	119 (2.6)	66 (1.8)	257 (2.2)	
	Bladder	35 (0.8)	24 (0.7)	88 (0.7)	
	Gynaecological	547 (12.1)	439 (12.0)	1183 (10.0)	
	Breast	962 (21.3)	723 (19.8)	2211 (18.7)	
Treatment factors					
Neoadjuvant therapy	No neoadjuvant	4177 (92.4)	3187 (87.4)	9600 (81.2)	<0.001
	Neoadjuvant therapy, standard care	272 (6.0)	340 (9.3)	1287 (10.9)	
	Neoadjuvant therapy, COVID decision	72 (1.6)	119 (3.3)	940 (7.9)	

Percentages expressed of column total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative

case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings.

Supplementary table 3. Characteristics of operated and non-operated patients during COVID-19

		Status at cessation of follow-up		
Factor	**Levels**	**Non-operated**	**Operated**	**P-value**
Health system factors				
COVID-19 Stringency Index group	Light restrictions	26 (1.3)	4495 (25.0)	<0.001
	Moderate lockdown	201 (10.0)	3445 (19.1)	
	Full lockdown	1775 (88.7)	10052 (55.9)	
Weeks in lockdown (COVID-19 stringency index)	Mean (SD)	20.3 (5.7)	7.8 (5.0)	<0.001
World Bank Income Classification	High income	1342 (67.0)	14521 (80.7)	<0.001
	Upper middle income	187 (9.3)	1704 (9.5)	
	Lower middle income	473 (23.6)	1776 (9.9)	
Community SARS-CoV-2 case notification rate*	High income, low COVID	1297 (64.8)	10103 (56.1)	<0.001
	High income, high COVID	58 (2.9)	680 (3.8)	
	Upper middle income, low COVID	129 (6.4)	1024 (5.7)	
	Upper middle income, high COVID	82 (4.1)	1508 (8.4)	
	Lower middle income, low COVID	391 (19.5)	268 (1.5)	
	Lower middle income, high COVID	45 (2.2)	4418 (24.5)	
Patient factors				
Age	<50 years	405 (20.2)	3287 (18.3)	0.001
	50-59 years	399 (19.9)	3739 (20.8)	
	60-69 years	555 (27.7)	4865 (27.0)	
	70-79 years	424 (21.2)	4422 (24.6)	
	>80 years	220 (11.0)	1690 (9.4)	
Sex	Female	1008 (50.3)	10472 (58.2)	<0.001
	Male	995 (49.7)	7531 (41.8)	
ASA Grade	Grade 1-2	1380 (70.8)	12777 (71.1)	0.822
	Grade 3-5	568 (29.2)	5190 (28.9)	
	Missing	55	36	
ECOG Performance Score	0	1004 (51.5)	10541 (59.6)	<0.001
	1	622 (31.9)	5217 (29.5)	
	≥2	325 (16.7)	1938 (11.0)	
	Missing	52	307	
Current smoker	No	1741 (86.9)	15933 (88.5)	0.04
	Yes	262 (13.1)	2070 (11.5)	
Pre-existing respiratory condition	No	1801 (89.9)	15948 (88.6)	0.081
	Yes	202 (10.1)	2055 (11.4)	
Revised Cardiac Risk Index	0	537 (26.8)	5544 (30.8)	<0.001
	1	1048 (52.3)	9202 (51.1)	
	2	336 (16.8)	2582 (14.3)	
	≥3	82 (4.1)	675 (3.7)	
Disease factors				
Disease stage	Early disease	889 (53.3)	9886 (55.1)	0.164
	Advanced/nodal disease	778 (46.7)	8045 (44.9)	
	Missing	336	72	
Site specific cancer	Head and neck	344 (17.2)	3173 (17.6)	<0.001
	Colon	170 (8.5)	3260 (18.1)	
	Rectal	188 (9.4)	1325 (7.4)	
	Gastric	75 (3.7)	648 (3.6)	
	Oesophageal	125 (6.2)	326 (1.8)	
	Thoracic	124 (6.2)	1068 (5.9)	
	Liver	77 (3.8)	698 (3.9)	
	Pancreatic	145 (7.2)	631 (3.5)	
	Sarcoma	49 (2.4)	389 (2.2)	
	Prostate	93 (4.6)	444 (2.5)	
	Kidney or upper tract urothelial	69 (3.4)	373 (2.1)	
	Bladder	40 (2.0)	107 (0.6)	
	Gynaecological	183 (9.1)	1986 (11.0)	
	Breast	321 (16.0)	3575 (19.9)	
Treatment factors				
Neoadjuvant therapy	No neoadjuvant	1353 (67.5)	15622 (86.8)	<0.001
	Neoadjuvant therapy, standard care	164 (8.2)	1736 (9.6)	
	Neoadjuvant therapy, COVID decision	486 (24.3)	645 (3.6)	

Percentages expressed of column total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients.

Supplementary table 4. Multivariable cox proportionate regression model of factors associated with surgical capacity during COVID-19 (presented in Figure 2)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group	Light restrictions	4520	-	-
	Moderate lockdown	3622	***0.78 (0.74-0.81, p<0.001)***	***0.81 (0.77-0.84, p<0.001)***
	Full lockdown	11678	***0.47 (0.46-0.49, p<0.001)***	***0.51 (0.50-0.53, p<0.001)***
World Bank Income Classification	High income	15733	-	-
	Upper middle income	1864	***0.93 (0.88-0.98, p=0.004)***	0.97 (0.92-1.02, p=0.220)
	Lower middle income	2232	***0.74 (0.70-0.78, p<0.001)***	***0.83 (0.78-0.87, p<0.001)***
Age	<50 years	3669	-	-
	50-59 years	4102	***1.07 (1.02-1.13, p=0.003)***	***1.10 (1.05-1.15, p<0.001)***
	60-69 years	5362	***1.05 (1.00-1.10, p=0.037)***	***1.09 (1.04-1.14, p=0.001)***
	70-79 years	4804	***1.12 (1.07-1.17, p<0.001)***	***1.17 (1.11-1.23, p<0.001)***
	>80 years	1895	1.06 (1.00-1.12, p=0.066)	1.06 (0.99-1.14, p=0.077)
Sex	Female	11398	-	-
	Male	8434	***0.89 (0.86-0.92, p<0.001)***	0.99 (0.95-1.02, p=0.457)
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.98 (0.95-1.02, p=0.307)	0.99 (0.95-1.03, p=0.533)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.93 (0.90-0.96, p<0.001)***	***0.96 (0.92-0.99, p=0.020)***
	≥2	2247	***0.90 (0.86-0.95, p<0.001)***	***0.89 (0.84-0.94, p<0.001)***
Current smoker	No	17521	-	-
	Yes	2311	1.04 (0.99-1.09, p=0.108)	1.03 (0.99-1.08, p=0.171)
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.97-1.07, p=0.391)	0.98 (0.94-1.03, p=0.472)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.90 (0.87-0.93, p<0.001)***	1.01 (0.95-1.07, p=0.779)
	2	2882	***0.87 (0.83-0.91, p<0.001)***	0.96 (0.89-1.03, p=0.245)
	≥3	754	***0.85 (0.78-0.92, p<0.001)***	***0.90 (0.81-1.00, p=0.044)***
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	***0.96 (0.93-0.99, p=0.008)***	***0.96 (0.93-0.99, p=0.018)***
Cancer location	Head and neck	3505	-	-
	Colon	3419	***1.21 (1.15-1.27, p<0.001)***	***1.16 (1.08-1.24, p<0.001)***
	Rectal	1491	***0.63 (0.59-0.67, p<0.001)***	***0.59 (0.54-0.64, p<0.001)***
	Gastric	717	***0.69 (0.63-0.75, p<0.001)***	***0.67 (0.61-0.74, p<0.001)***
	Oesophageal	444	***0.33 (0.30-0.37, p<0.001)***	***0.32 (0.28-0.36, p<0.001)***
	Thoracic	1184	***0.93 (0.87-1.00, p=0.036)***	***0.82 (0.76-0.90, p<0.001)***
	Liver	762	***0.69 (0.63-0.75, p<0.001)***	***0.63 (0.57-0.69, p<0.001)***
	Pancreatic	749	***0.75 (0.69-0.82, p<0.001)***	***0.73 (0.66-0.81, p<0.001)***
	Sarcoma	426	***0.71 (0.64-0.79, p<0.001)***	***0.67 (0.60-0.75, p<0.001)***
	Prostate	522	***0.51 (0.47-0.57, p<0.001)***	***0.44 (0.40-0.50, p<0.001)***
	Kidney or upper tract urothelial	433	***0.72 (0.65-0.80, p<0.001)***	***0.65 (0.57-0.73, p<0.001)***
	Bladder	142	***0.59 (0.49-0.72, p<0.001)***	***0.51 (0.42-0.62, p<0.001)***
	Gynaecological	2159	***0.95 (0.90-1.00, p=0.062)***	***0.86 (0.79-0.93, p<0.001)***
	Breast	3879	***0.88 (0.84-0.92, p<0.001)***	1.00 (0.94-1.05, p=0.884)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 17597, Concordance = 0.627 (SE = 0.002), R-squared = 0.147 (Max possible = 1.000), Likelihood ratio test = 3027.320 (df = 31, p = 0.000)

Supplementary table 5. Sensitivity analysis of primary model for factors associated with surgical capacity during COVID-19 (outcome definition including elective surgery only)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group	Light restrictions	4520	-	-
	Moderate lockdown	3622	***0.78 (0.75-0.82, p<0.001)***	***0.82 (0.78-0.86, p<0.001)***
	Full lockdown	11678	***0.48 (0.46-0.49, p<0.001)***	***0.53 (0.51-0.55, p<0.001)***
World Bank Income Classification	High income	15733	-	-
	Upper middle income	1864	***0.84 (0.80-0.89, p<0.001)***	***0.87 (0.82-0.92, p<0.001)***
	Lower middle income	2232	***0.72 (0.69-0.76, p<0.001)***	***0.80 (0.75-0.84, p<0.001)***
Age	<50 years	3669	-	-
	50-59 years	4102	***1.09 (1.03-1.14, p=0.001)***	***1.11 (1.06-1.17, p<0.001)***
	60-69 years	5362	***1.05 (1.01-1.10, p=0.027)***	***1.10 (1.05-1.16, p<0.001)***
	70-79 years	4804	***1.13 (1.08-1.18, p<0.001)***	***1.19 (1.13-1.26, p<0.001)***
	>80 years	1895	1.05 (0.99-1.11, p=0.124)	***1.08 (1.01-1.15, p=0.033)***
Sex	Female	11398	-	-
	Male	8434	***0.87 (0.84-0.90, p<0.001)***	0.98 (0.95-1.02, p=0.388)
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.97 (0.94-1.00, p=0.059)	0.98 (0.94-1.02, p=0.281)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.91 (0.88-0.94, p<0.001)***	***0.95 (0.92-0.99, p=0.006)***
	≥2	2247	***0.86 (0.82-0.91, p<0.001)***	***0.87 (0.82-0.92, p<0.001)***
Current smoker	No	17521	-	-
	Yes	2311	1.03 (0.98-1.08, p=0.273)	1.02 (0.98-1.08, p=0.331)
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.98-1.07, p=0.323)	0.99 (0.94-1.04, p=0.607)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.87 (0.84-0.90, p<0.001)***	1.00 (0.94-1.07, p=0.886)
	2	2882	***0.82 (0.78-0.86, p<0.001)***	0.94 (0.87-1.02, p=0.138)
	≥3	754	***0.80 (0.73-0.87, p<0.001)***	***0.89 (0.79-0.99, p=0.026)***
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	***0.93 (0.90-0.96, p<0.001)***	***0.94 (0.91-0.97, p<0.001)***
Cancer location	Head and neck	3505	-	-
	Colon	3419	***1.14 (1.08-1.19, p<0.001)***	***1.08 (1.00-1.16, p=0.040)***
	Rectal	1491	***0.60 (0.57-0.65, p<0.001)***	***0.57 (0.52-0.62, p<0.001)***
	Gastric	717	***0.66 (0.61-0.73, p<0.001)***	***0.65 (0.59-0.72, p<0.001)***
	Oesophageal	444	***0.33 (0.30-0.37, p<0.001)***	***0.31 (0.28-0.36, p<0.001)***
	Thoracic	1184	0.95 (0.89-1.02, p=0.153)	***0.83 (0.76-0.90, p<0.001)***
	Liver	762	***0.68 (0.63-0.74, p<0.001)***	***0.62 (0.56-0.68, p<0.001)***
	Pancreatic	749	***0.74 (0.68-0.81, p<0.001)***	***0.71 (0.64-0.79, p<0.001)***
	Sarcoma	426	***0.72 (0.64-0.80, p<0.001)***	***0.67 (0.59-0.75, p<0.001)***
	Prostate	522	***0.53 (0.48-0.58, p<0.001)***	***0.44 (0.39-0.50, p<0.001)***
	Kidney or upper tract urothelial	433	***0.67 (0.59-0.74, p<0.001)***	***0.59 (0.52-0.67, p<0.001)***
	Bladder	142	***0.58 (0.48-0.71, p<0.001)***	***0.50 (0.41-0.62, p<0.001)***
	Gynaecological	2159	0.95 (0.90-1.01, p=0.083)	***0.85 (0.79-0.93, p<0.001)***
	Breast	3879	***0.90 (0.85-0.94, p<0.001)***	1.01 (0.96-1.07, p=0.729)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 16754, Concordance = 0.627 (SE = 0.002), R-squared = 0.143(Max possible = 1.000), Likelihood ratio test = 2931.812 (df = 31, p = 0.000)

Supplementary table 6. Sensitivity analysis of primary model for factors associated with surgical capacity during COVID-19 (cancer location removed)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group	Light restrictions	4520	-	-
	Moderate lockdown	3622	***0.78 (0.74-0.81, p<0.001)***	***0.80 (0.76-0.83, p<0.001)***
	Full lockdown	11678	***0.47 (0.46-0.49, p<0.001)***	***0.51 (0.49-0.53, p<0.001)***
World Bank Income Classification	High income	15733	-	-
	Upper middle income	1864	***0.93 (0.88-0.98, p=0.004)***	1.01 (0.96-1.06, p=0.733)
	Lower middle income	2232	***0.74 (0.70-0.78, p<0.001)***	***0.86 (0.81-0.90, p<0.001)***
Age	<50 years	3669	-	-
	50-59 years	4102	***1.07 (1.02-1.13, p=0.003)***	***1.08 (1.03-1.14, p=0.001)***
	60-69 years	5362	***1.05 (1.00-1.10, p=0.037)***	***1.07 (1.02-1.12, p=0.005)***
	70-79 years	4804	***1.12 (1.07-1.17, p<0.001)***	***1.19 (1.13-1.25, p<0.001)***
	>80 years	1895	***1.06 (1.00-1.12, p=0.066)***	***1.17 (1.09-1.25, p<0.001)***
Sex	Female	11398	-	-
	Male	8434	***0.89 (0.86-0.92, p<0.001)***	***0.88 (0.85-0.90, p<0.001)***
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.98 (0.95-1.02, p=0.307)	1.01 (0.97-1.05, p=0.547)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.93 (0.90-0.96, p<0.001)***	0.97 (0.93-1.00, p=0.088)
	≥2	2247	***0.90 (0.86-0.95, p<0.001)***	***0.95 (0.89-1.00, p=0.047)***
Current smoker	No	17521	-	-
	Yes	2311	1.04 (0.99-1.09, p=0.108)	***1.06 (1.01-1.11, p=0.023)***
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.97-1.07, p=0.391)	1.00 (0.95-1.05, p=0.880)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.90 (0.87-0.93, p<0.001)***	***0.80 (0.77-0.83, p<0.001)***
	2	2882	***0.87 (0.83-0.91, p<0.001)***	***0.76 (0.72-0.80, p<0.001)***
	≥3	754	***0.85 (0.78-0.92, p<0.001)***	***0.75 (0.69-0.82, p<0.001)***
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	***0.96 (0.93-0.99, p=0.008)***	0.98 (0.95-1.01, p=0.190)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 17597, Concordance = 0.596 (SE = 0.003), R-squared = 0.095(Max possible = 1.000), Likelihood ratio test = 1893.143 (df = 18, p = 0.000).

Supplementary table 7a. Sensitivity analysis of factors associated with surgical capacity during COVID-19 (World Bank Income groups, with interaction term by COVID-19 stringency index group)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
Full lockdown * Upper middle income	Interaction	-	***0.85 (0.74-0.99, p=0.033)***	***0.85 (0.73-0.99, p=0.031)***
Full lockdown * Lower middle income	Interaction	-	0.88 (0.75-1.02, p=0.096)	***0.83 (0.71-0.97, p=0.019)***
Moderate lockdown * Upper middle income	Interaction	-	***0.57 (0.47-0.68, p<0.001)***	***0.64 (0.54-0.77, p<0.001)***
Moderate lockdown * Lower middle income	Interaction	-	1.09 (0.88-1.34, p=0.430)	***1.29 (1.04-1.59, p=0.019)***
COVID-19 Stringency Index group	Light restrictions	4520	-	-
	Moderate lockdown	3622	***0.81 (0.77-0.85, p<0.001)***	***0.82 (0.78-0.86, p<0.001)***
	Full lockdown	11678	***0.48 (0.47-0.50, p<0.001)***	***0.52 (0.50-0.55, p<0.001)***
World Bank Income Classification	High income	15733	-	-
	Upper middle income	1864	***1.27 (1.11-1.45, p=0.001)***	***1.17 (1.02-1.34, p=0.021)***
	Lower middle income	2232	0.95 (0.83-1.10, p=0.511)	0.94 (0.81-1.08, p=0.396)
Age	<50 years	3669	-	-
	50-59 years	4102	***1.07 (1.02-1.13, p=0.003)***	***1.10 (1.05-1.15, p<0.001)***
	60-69 years	5362	***1.05 (1.00-1.10, p=0.037)***	***1.09 (1.04-1.14, p<0.001)***
	70-79 years	4804	***1.12 (1.07-1.17, p<0.001)***	***1.17 (1.11-1.23, p<0.001)***
	>80 years	1895	1.06 (1.00-1.12, p=0.066)	1.07 (1.00-1.14, p=0.067)
Sex	Female	11398	-	-
	Male	8434	***0.89 (0.86-0.92, p<0.001)***	0.99 (0.95-1.03, p=0.562)
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.98 (0.95-1.02, p=0.307)	0.98 (0.95-1.02, p=0.419)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.93 (0.90-0.96, p<0.001)***	***0.96 (0.92-0.99, p=0.017)***
	≥2	2247	***0.90 (0.86-0.95, p<0.001)***	***0.89 (0.84-0.94, p<0.001)***
Current smoker	No	17521	-	-
	Yes	2311	1.04 (0.99-1.09, p=0.108)	1.04 (0.99-1.09, p=0.144)
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.97-1.07, p=0.391)	0.98 (0.94-1.03, p=0.478)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.90 (0.87-0.93, p<0.001)***	1.00 (0.94-1.07, p=0.897)
	2	2882	***0.87 (0.83-0.91, p<0.001)***	0.95 (0.88-1.03, p=0.221)
	≥3	754	***0.85 (0.78-0.92, p<0.001)***	0.90 (0.81-0.99, p=0.038)
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	***0.96 (0.93-0.99, p=0.008)***	***0.96 (0.93-1.00, p=0.025)***
Cancer location	Head and neck	3505	-	-
	Colon	3419	***1.21 (1.15-1.27, p<0.001)***	***1.15 (1.07-1.23, p<0.001)***
	Rectal	1491	***0.63 (0.59-0.67, p<0.001)***	***0.58 (0.54-0.63, p<0.001)***
	Gastric	717	***0.69 (0.63-0.75, p<0.001)***	***0.67 (0.61-0.74, p<0.001)***
	Oesophageal	444	***0.33 (0.30-0.37, p<0.001)***	***0.32 (0.28-0.36, p<0.001)***
	Thoracic	1184	***0.93 (0.87-1.00, p=0.036)***	***0.82 (0.75-0.90, p<0.001)***
	Liver	762	***0.69 (0.63-0.75, p<0.001)***	***0.62 (0.57-0.69, p<0.001)***
	Pancreatic	749	***0.75 (0.69-0.82, p<0.001)***	***0.73 (0.66-0.81, p<0.001)***
	Sarcoma	426	***0.71 (0.64-0.79, p<0.001)***	***0.67 (0.59-0.75, p<0.001)***
	Prostate	522	***0.51 (0.47-0.57, p<0.001)***	***0.44 (0.40-0.50, p<0.001)***
	Kidney or upper tract urothelial	433	***0.72 (0.65-0.80, p<0.001)***	***0.65 (0.57-0.73, p<0.001)***
	Bladder	142	***0.59 (0.49-0.72, p<0.001)***	***0.52 (0.43-0.64, p<0.001)***
	Gynaecological	2159	0.95 (0.90-1.00, p=0.062)	***0.85 (0.79-0.92, p<0.001)***
	Breast	3879	***0.88 (0.84-0.92, p<0.001)***	0.98 (0.93-1.04, p=0.501)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 17597, Concordance = 0.629 (SE = 0.002), R-squared = 0.149(Max possible = 1.000), Likelihood ratio test = 3082.513 (df = 35, p = 0.000)

Supplementary table 7b. Sensitivity analysis of factors associated with surgical capacity during COVID-19 (World Bank Income groups, with stratified hazard ratios by stringency index group)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group by income group	Light restrictions * High income	4088	-	-
	Light restrictions * Upper middle income	228	***1.27 (1.11-1.45, p=0.001)***	***1.17 (1.02-1.34, p=0.021)***
	Light restrictions * Lower middle income	204	0.95 (0.83-1.10, p=0.511)	0.94 (0.81-1.08, p=0.396)
	Moderate lockdown * High income	3116	***0.81 (0.77-0.85, p<0.001)***	***0.82 (0.78-0.86, p<0.001)***
	Moderate lockdown * Upper middle income	316	***0.58 (0.51-0.66, p<0.001)***	***0.62 (0.55-0.70, p<0.001)***
	Moderate lockdown * Lower middle income	190	0.84 (0.72-0.98, p=0.024)	1.00 (0.85-1.16, p=0.960)
	Full lockdown * High income	8529	***0.48 (0.47-0.50, p<0.001)***	***0.52 (0.50-0.55, p<0.001)***
	Full lockdown * Upper middle income	1311	***0.52 (0.49-0.56, p<0.001)***	***0.52 (0.49-0.56, p<0.001)***
	Full lockdown * Lower middle income	1838	***0.41 (0.38-0.43, p<0.001)***	***0.41 (0.38-0.44, p<0.001)***
Age	<50 years	3669	-	-
	50-59 years	4102	***1.07 (1.02-1.13, p=0.003)***	***1.10 (1.05-1.15, p<0.001)***
	60-69 years	5362	***1.05 (1.00-1.10, p=0.037)***	***1.09 (1.04-1.14, p<0.001)***
	70-79 years	4804	***1.12 (1.07-1.17, p<0.001)***	***1.17 (1.11-1.23, p<0.001)***
	>80 years	1895	1.06 (1.00-1.12, p=0.066)	1.07 (1.00-1.14, p=0.067)
Sex	Female	11398	-	-
	Male	8434	***0.89 (0.86-0.92, p<0.001)***	0.99 (0.95-1.03, p=0.562)
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.98 (0.95-1.02, p=0.307)	0.98 (0.95-1.02, p=0.419)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.93 (0.90-0.96, p<0.001)***	***0.96 (0.92-0.99, p=0.017)***
	≥2	2247	***0.90 (0.86-0.95, p<0.001)***	***0.89 (0.84-0.94, p<0.001)***
Current smoker	No	17521	-	-
	Yes	2311	1.04 (0.99-1.09, p=0.108)	1.04 (0.99-1.09, p=0.144)
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.97-1.07, p=0.391)	0.98 (0.94-1.03, p=0.478)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.90 (0.87-0.93, p<0.001)***	1.00 (0.94-1.07, p=0.897)
	2	2882	***0.87 (0.83-0.91, p<0.001)***	0.95 (0.88-1.03, p=0.221)
	≥3	754	***0.85 (0.78-0.92, p<0.001)***	***0.90 (0.81-0.99, p=0.038)***
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	***0.96 (0.93-0.99, p=0.008)***	***0.96 (0.93-1.00, p=0.025)***
Cancer location	Head and neck	3505	-	-
	Colon	3419	***1.21 (1.15-1.27, p<0.001)***	***1.15 (1.07-1.23, p<0.001)***
	Rectal	1491	***0.63 (0.59-0.67, p<0.001)***	***0.58 (0.54-0.63, p<0.001)***
	Gastric	717	***0.69 (0.63-0.75, p<0.001)***	***0.67 (0.61-0.74, p<0.001)***
	Oesophageal	444	***0.33 (0.30-0.37, p<0.001)***	***0.32 (0.28-0.36, p<0.001)***
	Thoracic	1184	***0.93 (0.87-1.00, p=0.036)***	***0.82 (0.75-0.90, p<0.001)***
	Liver	762	***0.69 (0.63-0.75, p<0.001)***	***0.62 (0.57-0.69, p<0.001)***
	Pancreatic	749	***0.75 (0.69-0.82, p<0.001)***	***0.73 (0.66-0.81, p<0.001)***
	Sarcoma	426	***0.71 (0.64-0.79, p<0.001)***	***0.67 (0.59-0.75, p<0.001)***
	Prostate	522	***0.51 (0.47-0.57, p<0.001)***	***0.44 (0.40-0.50, p<0.001)***
	Kidney or upper tract urothelial	433	***0.72 (0.65-0.80, p<0.001)***	***0.65 (0.57-0.73, p<0.001)***
	Bladder	142	***0.59 (0.49-0.72, p<0.001)***	***0.52 (0.43-0.64, p<0.001)***
	Gynaecological	2159	0.95 (0.90-1.00, p=0.062)	***0.85 (0.79-0.92, p<0.001)***
	Breast	3879	***0.88 (0.84-0.92, p<0.001)***	0.98 (0.93-1.04, p=0.501)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 17597, Concordance = 0.629 (SE = 0.002), R-squared = 0.149(Max possible = 1.000), Likelihood ratio test = 3082.513 (df = 35, p = 0.000)

Supplementary table 9. Differences in proportions of patients in each age group across settings

	Age group									
	<50 years*		50-59 years		60-69 years		70-79 years		>80 years	
Status at cessation of follow-up **SARS-CoV-2 case notification rate group**	**Not operated**	**Operated**	**Not operated**	**Operated**	**Not operated**	**Operated**	**Not operated**	**Operated**	**Not operated**	**Operated**
High income, low COVID	10 (2.5)	685 (20.8)	9 (2.3)	925 (24.7)	13 (2.3)	1228 (25.3)	6 (1.4)	1135 (25.7)	7 (3.2)	445 (26.3)
High income, high COVID	153 (37.8)	1296 (39.4)	203 (51.0)	1904 (50.9)	390 (70.3)	2832 (58.2)	358 (84.4)	2905 (65.7)	193 (87.7)	1166 (69.0)
Upper middle income, low COVID	9 (2.2)	208 (6.3)	12 (3.0)	160 (4.3)	20 (3.6)	186 (3.8)	13 (3.1)	97 (2.2)	4 (1.8)	29 (1.7)
Upper middle income, high COVID	33 (8.1)	287 (8.7)	35 (8.8)	241 (6.4)	35 (6.3)	293 (6.0)	18 (4.2)	167 (3.8)	8 (3.6)	36 (2.1)
Lower middle income, low COVID	24 (5.9)	679 (20.7)	29 (7.3)	441 (11.8)	19 (3.4)	276 (5.7)	8 (1.9)	100 (2.3)	2 (0.9)	12 (0.7)
Lower middle income, high COVID	***176 (43.5)***	132 (4.0)	***110 (27.6)***	68 (1.8)	78 (14.1)	48 (1.0)	21 (5.0)	18 (0.4)	6 (2.7)	2 (0.1)

COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Included patients <50 years of age, and 50-59 years of age were more likely to be from lower middle income countries. This may explain the reduced odds of patients <50 years undergoing surgery during the follow-up window (residual confounding after multivariable adjustment).

Supplementary table 10. Reasons that patients remained non-operated <50 versus >50 years of age

Reasons	<50 years (N=405)		≥ 50 years (N=1598)		Total
	N=	Proportion (%)	N=	Proportion (%)	N=
COVID-19 related					
Multidisciplinary team decision to delay surgery due to patient risk during COVID-19	335	***82.7%***	1121	70.2%	1456
Change to alternative treatment modality because of COVID-19	48	11.9%	485	30.4%	533
Patient choice to avoid surgery during COVID-19 pandemic	72	17.8%	388	24.3%	460
Ongoing neoadjuvant therapy (COVID-decision)	94	***23.2%***	284	17.8%	378
No bed/critical care bed/operating room space available due to COVID-19	87	***21.5%***	212	13.3%	299
Change of recommendations in society guidelines related to COVID-19	42	10.4%	178	11.1%	220
Patient unable to travel to hospital related to COVID- 19	67	***16.5%***	73	4.6%	140
Collateral impact on supporting services causing delay	3	0.7%	21	1.3%	24
Patient delayed due to SARS-CoV-2 infection	2	0.5%	21	1.3%	23
Died of COVID-19 whilst waiting for surgery	0	0.0%	13	0.8%	13
Not COVID-19 related					
Disease progression leading to change in treatment plan	10	2.5%	154	9.6%	164
Delay due to other medical or surgical condition	3	0.7%	56	3.5%	59
Died unrelated to COVID-19 whilst waiting for surgery	6	1.5%	29	1.8%	35
Patient unable to afford surgery	5	1.2%	19	1.2%	24
Patient choice to avoid surgery unrelated to COVID-19	5	***1.2%***	14	0.9%	19
Disease regression leading to change in definitive treatment plan	1	0.2%	7	0.4%	8

COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. Reasons which were more common in the <50 years age group are highlighted in bold. Two patients (0.1%) had no reasons given for non-operation during the follow-up window selected (missing data). Proportions are therefore expressed as a percentage of 2001 non-operated patients with that reason given and with data available. We anticipated that decisions to delay or cancel surgery during COVID-19 would be complex. Therefore, selecting more than one reason for non-operation during the follow-up window for each patient was permitted. One patient could have both one or more COVID-19 related and not COVID-related reason(s) selected.

Supplementary table 11. Sensitivity analysis of primary model for factors associated with surgical capacity during COVID-19 (patients >50 years old only, N=16163)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group	Light restrictions	3745	-	-
	Moderate lockdown	3061	***0.78 (0.75-0.82, p<0.001)***	***0.81 (0.77-0.85, p<0.001)***
	Full lockdown	9345	***0.48 (0.46-0.50, p<0.001)***	***0.52 (0.49-0.54, p<0.001)***
World Bank Income Classification	High income	13603	-	-
	Upper middle income	1331	***0.93 (0.88-0.99, p=0.017)***	0.95 (0.90-1.01, p=0.113)
	Lower middle income	1226	***0.78 (0.73-0.84, p<0.001)***	***0.87 (0.81-0.93, p<0.001)***
Age	50-59 years	4102	-	-
	60-69 years	5362	0.98 (0.94-1.02, p=0.272)	0.99 (0.95-1.04, p=0.795)
	70-79 years	4804	***1.04 (1.00-1.09, p=0.048)***	***1.07 (1.02-1.12, p=0.005)***
	>80 years	1895	0.98 (0.93-1.04, p=0.580)	0.97 (0.91-1.04, p=0.374)
Sex	Female	8828	-	-
	Male	7335	***0.88 (0.85-0.91, p<0.001)***	0.98 (0.94-1.02, p=0.404)
ASA Grade	Grade 1-2	10750	-	-
	Grade 3-5	5345	0.97 (0.93-1.00, p=0.056)	0.99 (0.95-1.03, p=0.529)
ECOG Performance Score	0	8578	-	-
	1	5160	***0.93 (0.89-0.96, p<0.001)***	***0.95 (0.92-0.99, p=0.014)***
	≥2	2122	***0.90 (0.86-0.95, p<0.001)***	***0.89 (0.84-0.94, p<0.001)***
Current smoker	No	14315	-	-
	Yes	1848	1.04 (0.99-1.10, p=0.114)	1.02 (0.97-1.08, p=0.385)
Pre-existing respiratory condition	No	14108	-	-
	Yes	2055	0.99 (0.94-1.04, p=0.686)	0.98 (0.93-1.03, p=0.393)
Revised Cardiac Risk Index	0	4079	-	-
	1	8581	***0.84 (0.81-0.87, p<0.001)***	1.01 (0.94-1.08, p=0.767)
	2	2756	***0.81 (0.77-0.85, p<0.001)***	0.96 (0.89-1.04, p=0.339)
	≥3	747	***0.79 (0.72-0.85, p<0.001)***	0.90 (0.81-1.01, p=0.069)
Disease stage	Early disease	8758	-	-
	Advanced/nodal disease	7109	***0.96 (0.93-1.00, p=0.030)***	***0.95 (0.92-0.99, p=0.007)***
Cancer location	Head and neck	2598	-	-
	Colon	3125	***1.10 (1.04-1.16, p=0.001)***	***1.10 (1.02-1.18, p=0.015)***
	Rectal	1307	***0.59 (0.55-0.63, p<0.001)***	***0.57 (0.53-0.63, p<0.001)***
	Gastric	610	***0.64 (0.58-0.70, p<0.001)***	***0.65 (0.58-0.72, p<0.001)***
	Oesophageal	408	***0.30 (0.26-0.34, p<0.001)***	***0.30 (0.26-0.34, p<0.001)***
	Thoracic	1099	***0.85 (0.79-0.92, p<0.001)***	***0.80 (0.73-0.87, p<0.001)***
	Liver	682	***0.64 (0.59-0.70, p<0.001)***	***0.61 (0.55-0.67, p<0.001)***
	Pancreatic	643	***0.70 (0.63-0.76, p<0.001)***	***0.70 (0.63-0.78, p<0.001)***
	Sarcoma	261	***0.64 (0.56-0.73, p<0.001)***	***0.60 (0.52-0.69, p<0.001)***
	Prostate	513	***0.47 (0.42-0.52, p<0.001)***	***0.43 (0.38-0.48, p<0.001)***
	Kidney or upper tract urothelial	370	***0.66 (0.58-0.74, p<0.001)***	***0.62 (0.54-0.70, p<0.001)***
	Bladder	127	***0.51 (0.42-0.63, p<0.001)***	***0.46 (0.37-0.57, p<0.001)***
	Gynaecological	1669	***0.87 (0.82-0.93, p<0.001)***	***0.81 (0.75-0.89, p<0.001)***
	Breast	2751	***0.83 (0.78-0.87, p<0.001)***	0.96 (0.90-1.02, p=0.164)

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 16163, Number in model = 15539, Missing = 624, Number of events = 14369, Concordance = 0.629 (SE = 0.003), R-squared = 0.152(Max possible = 1.000), Likelihood ratio test = 2566.579 (df = 30, p = 0.000)

Supplementary table 12. Non-operation rate during lockdowns across SARS-CoV-2 rate groups

	Full lockdown		Moderate lockdown		Light restrictions	
SARS-CoV-2 case notification rate group	**Operated**	**Not operated**	**Operated**	**Not operated**	**Operated**	**Not operated**
High income, low COVID	345 (94.0)	22 (6.0)	1138 (99.5)	6 (0.5)	2935 (99.4)	17 (0.6)
High income, high COVID	7111 (85.9)	1166 (14.1)	1860 (93.7)	126 (6.3)	1132 (99.6)	5 (0.4)
Upper middle income, low COVID	245 (93.5)	17 (6.5)	208 (83.9)	40 (16.1)	227 (99.6)	1 (0.4)
Upper middle income, high COVID	945 (88.6)	122 (11.4)	70 (90.9)	7 (9.1)	0 (0.0)	0 (0.0)
Lower middle income, low COVID	1138 (94.4)	67 (5.6)	169 (93.4)	12 (6.6)	201 (98.5)	3 (1.5)
Lower middle income, high COVID	268 (41.3)	381 (58.7)	0 (0.0)	10 (100.0)	0 (0.0)	0 (0.0)

COVID=Coronavirus disease 2019.

Supplementary table 13. Secondary analysis of factors associated with surgical capacity during COVID-19 (SARS-CoV-2 case notification rate groups)

Factor	Levels	N=	HR (univariable)	HR (multivariable)
COVID-19 Stringency Index group	Light restrictions	4520	-	-
	Moderate lockdown	3622	***0.78 (0.74-0.81, p<0.001)***	***0.84 (0.80-0.88, p<0.001)***
	Full lockdown	11678	***0.47 (0.46-0.49, p<0.001)***	***0.57 (0.54-0.60, p<0.001)***
Community SARS-CoV-2 case notification rate*	High income, low COVID	4459	-	-
	High income, high COVID	11274	***0.60 (0.58-0.62, p<0.001)***	***0.89 (0.85-0.93, p<0.001)***
	Upper middle income, low COVID	727	***0.77 (0.71-0.83, p<0.001)***	***0.91 (0.84-0.99, p=0.030)***
	Upper middle income, high COVID	1137	***0.57 (0.53-0.61, p<0.001)***	***0.85 (0.78-0.92, p<0.001)***
	Lower middle income, low COVID	1587	***0.76 (0.72-0.80, p<0.001)***	1.06 (0.99-1.14, p=0.076)
	Lower middle income, high COVID	645	***0.17 (0.15-0.20, p<0.001)***	***0.27 (0.24-0.31, p<0.001)***
Age	<50 years	3669	-	-
	50-59 years	4102	***1.07 (1.02-1.13, p=0.003)***	***1.11 (1.05-1.16, p<0.001)***
	60-69 years	5362	***1.05 (1.00-1.10, p=0.037)***	***1.09 (1.04-1.15, p<0.001)***
	70-79 years	4804	***1.12 (1.07-1.17, p<0.001)***	***1.18 (1.12-1.24, p<0.001)***
	>80 years	1895	1.06 (1.00-1.12, p=0.066)	1.06 (1.00-1.14, p=0.067)
Sex	Female	11398	-	-
	Male	8434	***0.89 (0.86-0.92, p<0.001)***	1.00 (0.97-1.04, p=0.938)
ASA Grade	Grade 1-2	14033	-	-
	Grade 3-5	5722	0.98 (0.95-1.02, p=0.307)	0.98 (0.94-1.02, p=0.267)
ECOG Performance Score	0	11445	-	-
	1	5789	***0.93 (0.90-0.96, p<0.001)***	***0.94 (0.91-0.98, p=0.002)***
	≥2	2247	***0.90 (0.86-0.95, p<0.001)***	***0.90 (0.85-0.95, p<0.001)***
Current smoker	No	17521	-	-
	Yes	2311	1.04 (0.99-1.09, p=0.108)	***1.05 (1.00-1.10, p=0.039)***
Pre-existing respiratory condition	No	17591	-	-
	Yes	2241	1.02 (0.97-1.07, p=0.391)	0.98 (0.93-1.03, p=0.417)
Revised Cardiac Risk Index	0	6059	-	-
	1	10137	***0.90 (0.87-0.93, p<0.001)***	1.00 (0.94-1.06, p=0.938)
	2	2882	***0.87 (0.83-0.91, p<0.001)***	0.94 (0.87-1.02, p=0.120)
	≥3	754	***0.85 (0.78-0.92, p<0.001)***	***0.88 (0.80-0.98, p=0.021)***
Disease stage	Early disease	10695	-	-
	Advanced/nodal disease	8748	0.96 (0.93-0.99, p=0.008)	***0.96 (0.93-0.99, p=0.012)***
Cancer location	Head and neck	3505	-	-
	Colon	3419	***1.21 (1.15-1.27, p<0.001)***	***1.13 (1.05-1.21, p=0.001)***
	Rectal	1491	***0.63 (0.59-0.67, p<0.001)***	***0.57 (0.52-0.62, p<0.001)***
	Gastric	717	***0.69 (0.63-0.75, p<0.001)***	***0.65 (0.59-0.72, p<0.001)***
	Oesophageal	444	***0.33 (0.30-0.37, p<0.001)***	***0.30 (0.27-0.35, p<0.001)***
	Thoracic	1184	***0.93 (0.87-1.00, p=0.036)***	***0.80 (0.73-0.87, p<0.001)***
	Liver	762	***0.69 (0.63-0.75, p<0.001)***	***0.60 (0.55-0.66, p<0.001)***
	Pancreatic	749	***0.75 (0.69-0.82, p<0.001)***	***0.70 (0.64-0.78, p<0.001)***
	Sarcoma	426	***0.71 (0.64-0.79, p<0.001)***	***0.63 (0.56-0.71, p<0.001)***
	Prostate	522	***0.51 (0.47-0.57, p<0.001)***	***0.42 (0.37-0.47, p<0.001)***
	Kidney or upper tract urothelial	433	***0.72 (0.65-0.80, p<0.001)***	***0.61 (0.54-0.69, p<0.001)***
	Bladder	142	***0.59 (0.49-0.72, p<0.001)***	***0.50 (0.41-0.62, p<0.001)***
	Gynaecological	2159	0.95 (0.90-1.00, p=0.062)	***0.85 (0.78-0.91, p<0.001)***
	Breast	3879	***0.88 (0.84-0.92, p<0.001)***	***0.91 (0.86-0.96, p<0.001)***

Surgical capacity defined as patients booked for surgery undergoing an operation during the follow-up window. Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. *Community SARS-CoV-2 rates were defined as the median 14-day cumulative case notification rate per 100,000 population between the date of local emergence of the pandemic up to the date of surgery for operated patients or cessation of follow-up (31st August 2020) for non-operated patients, and were stratified by World Bank income group to account for differences in access to SARS-CoV-2 testing and reporting across settings. Number in dataframe = 19832, Number in model = 19066, Missing = 766, Number of events = 17597, Concordance = 0.636 (SE = 0.002), R-squared = 0.171(Max possible = 1.000), Likelihood ratio test = 3574.260 (df = 34, p = 0.000)

Supplementary table 14. Treatment intervals across SARS-CoV-2 case notification rate groups

Interval diagnosis to surgery	High income, low COVID	High income, high COVID	Upper middle income, low COVID	Upper middle income, high COVID	Lower middle income, low COVID	Lower middle income, high COVID	P-value
Straight to surgery							
0-4 weeks	1263 (31.2)	2318 (26.6)	228 (37.9)	302 (32.5)	545 (49.5)	70 (33.0)	***<0.001***
5-8 weeks	1755 (43.4)	3111 (35.6)	175 (29.1)	207 (22.3)	295 (26.8)	53 (25.0)	
9-12 weeks	596 (14.7)	1632 (18.7)	99 (16.4)	131 (14.1)	121 (11.0)	22 (10.4)	
>12 weeks	432 (10.7)	1669 (19.1)	100 (16.6)	290 (31.2)	139 (12.6)	67 (31.6)	
Neoadjuvant therapy (standard care)							
0-4 weeks	29 (8.9)	64 (6.9)	7 (9.7)	1 (1.6)	7 (2.3)	2 (5.1)	***<0.001***
5-8 weeks	25 (7.7)	48 (5.1)	6 (8.3)	2 (3.2)	14 (4.6)	0 (0.0)	
9-12 weeks	37 (11.4)	73 (7.8)	11 (15.3)	4 (6.5)	15 (4.9)	1 (2.6)	
>12 weeks	234 (72.0)	749 (80.2)	48 (66.7)	55 (88.7)	268 (88.2)	36 (92.3)	
Neoadjuvant therapy (COVID decision)							
0-4 weeks	10 (21.3)	20 (4.6)	0 (0.0)	1 (3.1)	2 (1.9)	1 (5.9)	***<0.001***
5-8 weeks	10 (21.3)	78 (17.8)	0 (0.0)	2 (6.2)	6 (5.8)	3 (17.6)	
9-12 weeks	8 (17.0)	104 (23.7)	2 (33.3)	5 (15.6)	18 (17.3)	2 (11.8)	
>12 weeks	19 (40.4)	237 (54.0)	4 (66.7)	24 (75.0)	78 (75.0)	11 (64.7)	

Percentages presented by column total. COVID=Coronavirus disease 2019.

Supplementary table 15. System friction during lockdowns

Interval	Summary	Light restrictions	Moderate lockdown	Full lockdown	P-value
Straight to surgery					
Weeks diagnosis to operation	Mean (SD)	5.7 (4.4)	5.9 (4.6)	7.8 (5.9)	***<0.001***
Weeks diagnosis to decision	Mean (SD)	2.8 (3.5)	2.7 (3.5)	3.1 (3.9)	***<0.001***
Weeks decision to operation	Mean (SD)	2.9 (2.4)	3.2 (2.8)	4.7 (4.5)	***<0.001***
Neoadjuvant therapy (standard care)					
Weeks diagnosis to operation	Mean (SD)	15.3 (8.1)	15.8 (7.0)	17.4 (6.1)	***<0.001***
Weeks diagnosis to decision	Mean (SD)	11.6 (8.3)	9.7 (8.4)	9.7 (30.3)	0.488
Weeks decision to operation	Mean (SD)	3.7 (3.0)	6.1 (5.4)	9.4 (30.1)	***0.001***
Neoadjuvant therapy (COVID decision)					
Weeks diagnosis to operation	Mean (SD)	8.4 (6.5)	9.9 (6.2)	14.7 (6.1)	***<0.001***
Weeks diagnosis to decision	Mean (SD)	4.8 (6.9)	3.6 (5.8)	4.9 (5.8)	0.214
Weeks decision to operation	Mean (SD)	3.6 (3.3)	6.3 (4.6)	9.8 (5.9)	***<0.001***

Supplementary table 16. Characteristics of operated patients that went straight to surgery (no neoadjuvant therapy) grouped by time from diagnosis to operation (N=15622)

		Interval diagnosis to surgery				
Factor	**Levels**	**0-4 weeks**	**5-8 weeks**	**9-12 weeks**	**>12 weeks**	**P-value**
Health system factors						
COVID-19 Stringency Index group	Light restrictions	1372 (33.0)	1813 (43.7)	588 (14.2)	379 (9.1)	***<0.001***
	Moderate lockdown	1020 (33.4)	1244 (40.7)	476 (15.6)	317 (10.4)	
	Full lockdown	2333 (27.8)	2533 (30.1)	1535 (18.3)	2001 (23.8)	
Weeks in full lockdown	Mean (SD)	7.2 (4.9)	6.8 (4.8)	7.7 (4.5)	10.0 (5.0)	***<0.001***
World Bank Income Classification	High income	3581 (28.0)	4866 (38.1)	2228 (17.4)	2101 (16.4)	***<0.001***
	Upper middle income	530 (34.6)	382 (24.9)	230 (15.0)	390 (25.5)	
	Lower middle income	615 (46.9)	348 (26.5)	143 (10.9)	206 (15.7)	
SARS-CoV-2 case notification rate	High income, low COVID	1263 (31.2)	1755 (43.4)	596 (14.7)	432 (10.7)	***<0.001***
	High income, high COVID	2318 (26.6)	3111 (35.6)	1632 (18.7)	1669 (19.1)	
	Upper middle income, low COVID	228 (37.9)	175 (29.1)	99 (16.4)	100 (16.6)	
	Upper middle income, high COVID	302 (32.5)	207 (22.3)	131 (14.1)	290 (31.2)	
	Lower middle income, low COVID	545 (49.5)	295 (26.8)	121 (11.0)	139 (12.6)	
	Lower middle income, high COVID	70 (33.0)	53 (25.0)	22 (10.4)	67 (31.6)	
Patient factors						
Age	<50 years	940 (35.1)	852 (31.8)	409 (15.3)	480 (17.9)	***<0.001***
	50-59 years	1003 (31.5)	1174 (36.8)	493 (15.5)	519 (16.3)	
	60-69 years	1234 (29.2)	1525 (36.0)	723 (17.1)	749 (17.7)	
	70-79 years	1087 (27.7)	1501 (38.2)	698 (17.8)	644 (16.4)	
	>80 years	463 (29.1)	545 (34.3)	278 (17.5)	305 (19.2)	
Sex	Female	2726 (30.2)	3464 (38.4)	1441 (16.0)	1386 (15.4)	***<0.001***
	Male	2001 (30.3)	2133 (32.3)	1160 (17.6)	1311 (19.8)	
ASA Grade	ASA grade 1-2	3406 (30.9)	4005 (36.4)	1746 (15.9)	1853 (16.8)	***<0.001***
	ASA grade 3-5	1312 (28.6)	1576 (34.4)	851 (18.6)	841 (18.4)	
	Missing	9	19	5	3	
ECOG Performance Score	0	2778 (30.4)	3335 (36.5)	1439 (15.8)	1573 (17.2)	***0.002***
	1	1332 (29.6)	1590 (35.4)	810 (18.0)	764 (17.0)	
	≥2	560 (32.1)	567 (32.5)	297 (17.0)	321 (18.4)	
	Missing	60	110	68	69	
Current smoker	No	4153 (30.1)	4931 (35.7)	2294 (16.6)	2424 (17.6)	0.054
	Yes	574 (31.5)	666 (36.6)	307 (16.9)	273 (15.0)	
Pre-existing respiratory condition	No	4249 (30.8)	4920 (35.7)	2262 (16.4)	2355 (17.1)	***<0.001***
	Yes	478 (26.0)	677 (36.9)	339 (18.5)	342 (18.6)	
Revised Cardiac Risk Index	0	1534 (32.4)	1810 (38.3)	751 (15.9)	637 (13.5)	***<0.001***
	1	2372 (29.7)	2814 (35.3)	1310 (16.4)	1485 (18.6)	
	2	654 (28.6)	775 (33.9)	429 (18.8)	430 (18.8)	
	≥3	167 (26.9)	198 (31.9)	111 (17.9)	145 (23.3)	
Disease factors						
Disease stage	Early disease	2434 (27.0)	3271 (36.3)	1613 (17.9)	1685 (18.7)	***<0.001***
	Advanced/nodal disease	2271 (34.7)	2300 (35.1)	981 (15.0)	1002 (15.3)	
	Missing	22	29	9	12	
Cancer site	Head and neck	1011 (33.2)	1083 (35.6)	486 (16.0)	461 (15.2)	***<0.001***
	Colon	1221 (38.6)	1004 (31.7)	503 (15.9)	439 (13.9)	
	Rectal	232 (26.5)	306 (35.0)	130 (14.9)	206 (23.6)	
	Gastric	149 (32.7)	126 (27.6)	76 (16.7)	105 (23.0)	
	Oesophageal	26 (22.8)	32 (28.1)	13 (11.4)	43 (37.7)	
	Thoracic	242 (23.3)	427 (41.1)	187 (18.0)	184 (17.7)	
	Liver	98 (16.5)	182 (30.6)	153 (25.7)	162 (27.2)	
	Pancreatic	203 (35.4)	187 (32.6)	86 (15.0)	98 (17.1)	
	Sarcoma	78 (27.3)	79 (27.6)	57 (19.9)	72 (25.2)	
	Prostate	20 (5.0)	86 (21.4)	82 (20.4)	213 (53.1)	
	Kidney or upper tract urothelial	87 (23.4)	124 (33.3)	70 (18.8)	91 (24.5)	
	Bladder	14 (14.4)	39 (40.2)	27 (27.8)	17 (17.5)	
	Gynaecological	515 (28.4)	750 (41.4)	261 (14.4)	287 (15.8)	
	Breast	831 (29.8)	1172 (42.0)	470 (16.8)	319 (11.4)	
Treatment factors						
Operation grade	Major	3658 (29.7)	4303 (34.9)	2060 (16.7)	2297 (18.6)	***<0.001***
	Minor	1042 (32.4)	1268 (39.4)	530 (16.5)	381 (11.8)	
	Missing	21	22	10	18	

Percentages expressed of row total. SD=Standard deviation. ASA=American Society of Anaesthesiologists classification. ECOG=Eastern Cooperative Oncology Group. COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2.

Supplementary table 17. Outcomes by interval from diagnosis to operation for patients going straight to surgery (N=15622)

		Interval diagnosis to surgery					
Outcome	**Levels**	**0-4 weeks**	**5-8 weeks**	**9-12 weeks**	**>12 weeks**	**Total**	**P-value**
Margin status	R0	4043 (85.6)	4791 (85.8)	2222 (85.2)	2280 (84.7)	13336 (85.1)	***0.019***
	R1	328 (6.9)	441 (7.9)	202 (7.9)	217 (8.1)	1188 (7.7)	
	R2	100 (2.1)	107 (1.9)	53 (2.0)	37 (1.4)	297 (1.9)	
	Pathology unavailable	251 (5.3)	247 (4.4)	116 (4.5)	154 (5.7)	768 (4.9)	
	Missing	5	11	8	9	33	
Resectable disease at time of surgery	Resectable	4553 (96.3)	5508 (98.4)	2554 (98.2)	2645 (98.1)	15260 (97.7)	***<0.001***
	Unresectable	173 (3.7)	87 (1.6)	46 (1.8)	52 (1.9)	358 (2.3)	
	Unknown	1 (0.0)	2 (0.0)	1 (0.0)	0 (0.0)	4 (0.0)	
Pre-operative cancer-related complication requiring emergency surgery	Elective	4468 (94.7)	5547 (99.2)	2581 (99.4)	2674 (99.4)	15270 (97.9)	***<0.001***
	Emergency	252 (5.3)	43 (0.8)	16 (0.6)	15 (0.6)	326 (2.1)	
30-day SARS-CoV-2 infection rate	No	4685 (99.1)	5557 (99.3)	2577 (99.1)	2676 (99.2)	15495 (99.2)	0.698
	Yes	42 (0.9)	40 (0.7)	24 (0.9)	21 (0.8)	127 (0.8)	
30-day postoperative mortality rate	No	4652 (98.5)	5533 (98.9)	2570 (98.9)	2659 (98.9)	15414 (98.8)	***0.008***
	Yes	73 (1.5)	62 (1.1)	29 (1.1)	31 (1.1)	195 (1.2)	
	Missing	2	2	2	7	13	
New detection of metastatic disease*	No	2694 (98.1)	2967 (97.8)	1454 (98.7)	1656 (98.4)	8771 (98.1)	0.085
	Yes	51 (1.9)	66 (2.3)	18 (1.3)	24 (1.6)	159 (1.9)	
	Missing	4	5	4	14	27	

COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. Resection margin status classified as R0=No microscopic or macroscopic disease, R1=Microscopic disease at the margin, R2=Macroscopic disease at the margin. *Detailed data on detection of new metastatic disease not collected for liver, pancreatic, breast and gynaecological cancers. Patients with metastatic disease at baseline removed from denominator (N=8957). Chi-squared tests do not include missing data. Percentages presented by column total.

Supplementary table 18. Outcomes across SARS-CoV-2 case notification rate groups for patients going straight to surgery (no neoadjuvant therapy) (N=15622)

		SARS-CoV-2 case notification rate group							
Outcome	**Levels**	**High income, low COVID**	**High income, high COVID**	**Upper middle income, low COVID**	**Upper middle income, high COVID**	**Lower middle income, low COVID**	**Lower middle income, high COVID**	**Total**	**P-value**
Margin status	R0	3397 (84.1)	7462 (85.7)	509 (84.8)	797 (85.9)	975 (88.8)	194 (91.5)	13334 (85.5)	***<0.001***
	R1	372 (9.2)	683 (7.8)	35 (5.8)	66 (7.1)	28 (2.6)	4 (1.9)	1188 (7.7)	
	R2	90 (2.2)	144 (1.6)	14 (2.3)	30 (3.2)	17 (1.5)	2 (0.9)	297 (1.9)	
	Pathology unavailable	182 (4.5)	420 (4.8)	43 (7.1)	35 (3.8)	76 (7.0)	12 (5.7)	768 (4.9)	
	Missing	5	21	1	2	4	0	33	
Resectable disease at time of surgery	Resectable	3970 (98.1)	8567 (98.1)	580 (96.3)	895 (96.2)	1040 (94.5)	206 (97.2)	15258 (97.7)	***<0.001***
	Unresectable	74 (1.8)	161 (1.8)	22 (3.7)	35 (3.8)	60 (5.5)	6 (2.8)	358 (2.3)	
	Unknown	2 (0.0)	2 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.0)	
Pre-operative cancer-related complication requiring emergency surgery	Elective	3978 (98.4)	8562 (98.3)	581 (97.0)	893 (96.0)	1052 (95.7)	202 (95.3)	15268 (97.9)	***<0.001***
	Emergency	63 (1.6)	151 (1.7)	18 (3.0)	37 (4.0)	47 (4.3)	10 (4.7)	326 (2.1)	
30-day SARS-CoV-2 infection rate	No	3988 (98.6)	8697 (99.6)	601 (99.8)	916 (98.5)	1081 (98.3)	210 (99.1)	15493 (99.2)	***<0.001***
	Yes	58 (1.4)	33 (0.4)	1 (0.2)	14 (1.5)	19 (1.7)	2 (0.9)	127 (0.8)	
30-day postoperative mortality rate	No	3980 (98.4)	8641 (99.1)	594 (98.7)	917 (98.6)	1074 (97.6)	206 (97.2)	15412 (98.8)	***<0.001***
	Yes	65 (1.6)	77 (0.9)	8 (1.3)	13 (1.4)	26 (2.4)	6 (2.8)	195 (1.2)	
	Missing	1	12	0	0	0	0	13	
New detection of metastatic disease*	No	2223 (98.1)	5105 (98.2)	266 (97.4)	541 (97.7)	510 (97.9)	124 (98.4)	8769 (98.1)	0.741
	Yes	42 (1.9)	85 (1.8)	7 (2.6)	13 (2.3)	10 (2.1)	2 (1.6)	159 (1.9)	
	Missing	6	18	0	0	3	0	27	

COVID=Coronavirus disease 2019. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. Resection margin status classified as R0=No microscopic or macroscopic disease, R1=Microscopic disease at the margin, R2=Macroscopic disease at the margin. *Detailed data on detection of new metastatic disease not collected for liver, pancreatic, breast and gynaecological cancers. Patients with metastatic disease at baseline removed from denominator (N=8957). Percentages presented by column total.

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Appendix B. Definition of "lockdowns" in sample of participating countries

ISO3 code	Country	World Bank income group	Date of first lockdown (full or moderate)	COVID-19 stringency index score
ARE	United Arab Emirates	High income	Full, 26th March 2020	73.2
AUT	Austria	High income	Full, 16th March 2020	81.5
BEL	Belgium	High income	Full, 18th March 2020	73.2
BRB	Barbados	High income	Full, 28th March 2020	73.2
CAN	Canada	High income	Moderate (regional), 17th March 2020	43.5
CHE	Switzerland	High income	Full, 17th March 2020	73.2
CYP	Cyprus	High income	Full, 24th March 2020	92.6
CZE	Czech Republic	High income	Full, 16th March 2020	79.6
DEU	Germany	High income	Full, 22nd March 2020	76.9
DNK	Denmark	High income	Moderate (national), 12th March 2020	38.0
ESP	Spain	High income	Full, 14th March 2020	67.1
FRA	France	High income	Full, 17th March 2020	88.0
GBR	United Kingdom	High income	Full, 23rd March 2020	78.2
GRC	Greece	High income	Full, 23rd March 2020	84.3
HRV	Croatia	High income	Moderate (national), 19th March 2020	50.0
HUN	Hungary	High income	Full, 28th March 2020	76.9
IRL	Ireland	High income	Full, 28th March 2020	85.2
ITA	Italy	High income	Full, 9th March 2020	74.5
JPN	Japan	High income	Moderate (national) only, 7th April 2020	43.5
KWT	Kuwait	High income	Full, 10th May 2020	100.0
LTU	Lithuania	High income	Full, 16th March 2020	81.5
NLD	Netherlands	High income	Moderate (national), 15th March 2020	53.7
OMN	Oman	High income	Full, 10th April 2020	92.6
PAN	Panama	High income	Full, 25th March 2020	75.9
POL	Poland	High income	Moderate (national), 13th March 2020	41.7
PRT	Portugal	High income	Full, 19th March 2020	82.4
SAU	Saudi Arabia	High income	Moderate (regional), 9th March 2020	30.6
SGP	Singapore	High income	Full, 8th April 2020	76.9
USA	United States	High income	Moderate (regional) only 17 March 2020	55.1
ALB	Albania	Upper middle income	Full, 13th March 2020	78.7
ARG	Argentina	Upper middle income	Full, 19th March 2020	100.0
AZE	Azerbaijan	Upper middle income	Full, 31st March 2020	88.89
BGR	Bulgaria	Upper middle income	Moderate (national), 13th March 2020	50.93
BRA	Brazil	Upper middle income	Moderate (regional) only, 17th March 2020	57.9
BWA	Botswana	Upper middle income	Full, 2nd April 2020	86.11
COL	Colombia	Upper middle income	Full, 25th March 2020	87.96
JOR	Jordan	Upper middle income	Full, 18th March 2020	100
LBY	Libya	Upper middle income	Full, 22nd March 2020	77.78
LKA	Sri Lanka	Upper middle income	Full, 18th March 2020	81.48
MEX	Mexico	Upper middle income	Moderate (national), 24th March 2020	52.78
MYS	Malaysia	Upper middle income	Full, 18th March 2020	73.15
PER	Peru	Upper middle income	Full, 16th March 2020	90.74
ROU	Romania	Upper middle income	Full, 25th March 2020	78.7
RUS	Russian Federation	Upper middle income	Full, 28th March 2020	71.7
SRB	Serbia	Upper middle income	Moderate (national), 15th March 2020	49.07
TUR	Turkey	Upper middle income	Full, 28th March 2020	75.9
ZAF	South Africa	Upper middle income	Full, 26th March 2020	88
EGY	Egypt	Lower middle income	Full, 25th March 2020	84.3
ETH	Ethiopia	Lower middle income	Full, 8th April 2020	80.6
GHA	Ghana	Lower middle income	Moderate (regional) only, 26th March 2020	52.8
IND	India	Lower middle income	Full, 25th March 2020	100.0
MAR	Morocco	Lower middle income	Moderate (national), 19th March 2020	55.56
MDG	Madagascar	Lower middle income	Full, 23rd March 2020	91.67
NGA	Nigeria	Lower middle income	Moderate (regional) only, 23rd March 2020	48.6
PAK	Pakistan	Lower middle income	Full, 24th March 2020	93.5
PHL	Philippines	Lower middle income	Full, 15th March 2020	75.0
PSE	Palestine	Lower middle income	Full, 7th March 2020	74.07
TUN	Tunisia	Lower middle income	Full, 22nd March 2020	90.74

Appendix C. Indicators in the Oxford COVID-19 government response index

Indicator	Name	Type	Targeted/general?	Maximum value (levels)
Containment and closure				
C1	School closing	Ordinal	Geographic	3 (0, 1, 2, 3)
C2	Workplace closing	Ordinal	Geographic	3 (0, 1, 2, 3)
C3	Cancel public events	Ordinal	Geographic	2 (0, 1, 2)
C4	Restrictions on gathering size	Ordinal	Geographic	4 (0, 1, 2, 3, 4)
C5	Close public transport	Ordinal	Geographic	2 (0, 1, 2)
C6	Stay-at-home requirements	Ordinal	Geographic	3 (0, 1, 2, 3)
C7	Restrictions on internal movement	Ordinal	Geographic	2 (0, 1, 2)
C8	Restrictions on international travel	Ordinal	No	4 (0, 1, 2, 3, 4)
Economic response				
E1	Income support	Ordinal	Sectoral	2 (0, 1, 2)
E2	Debt/contract relief for households	Ordinal	No	2 (0, 1, 2)
Health systems				
H1	Public information campaign	Ordinal	Geographic	2 (0, 1, 2)
H2	Testing policy	Ordinal	No	3 (0, 1, 2, 3)
H3	Contact tracing	Ordinal	No	2 (0, 1, 2)
H6	Facial coverings	Ordinal	Geographic	4 (0, 1, 2, 3, 4)
H7	Vaccination policy	Ordinal	Funding	5 (0, 1, 2, 3, 4, 5)

13 indicators are included in the Oxford COVID-19 government response index (overall) which are used for this analysis. Published in Hale, T., Angrist, N., Goldszmidt, R. et al. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nat Hum Behav 5, 529–538 (2021). https://doi.org/10.1038/s41562-021-01079-8

Appendix D. Use of the Oxford COVID-19 Government Stringency index

In order to define the national government response to COVID-19 for each patient in each included country, we used the stringency index from the Oxford COVID-19 government response tracker. The COVID-19 stringency index is a data-driven tool for policy and research that measures how the response of governments has varied in response to COVID-19 at a national level with across 19 indicators including 'lockdown' measures and behavioural interventions aimed at reducing population mobility (1). The index has been validated by demonstrating associations with population SARS-CoV-2 infection rates and Google mobile phone mobility data. The stringency index was highly associated with population mobility in validation data and was best targeted towards the impact of restrictive governmental interventions on surgical capacity, so was chosen for use in this study.

In this study, three groupings of the level of 'lockdown' based on COVID-19 stringency index scores were adopted: (1) Light restrictions (index score <20); (2) Moderate lockdown (index score $20 \leq x \leq 60$); (3) Full lockdown (index score >60). Recognising variability in definitions of lockdown across included countries, the selection of a cut-point for a 'full lockdown' was validated by using national policy, media and press sources to identify the date of first national 'lockdown' for a sample of participating high-income, upper middle-income and lower middle-income countries, and extracting the point estimate for the COVID-19 stringency index score on the date of lockdown (***Appendix C***). If no 'full lockdown' was reported to have occurred, a representative date where some restrictive measures were imposed at either a national or regional level (i.e., a 'moderate lockdown') was selected. Whilst all participating hospitals were in areas affected by COVID-19, the definition of 'light restrictions' aimed to emulate 'normal circumstances' as closely as possible to allow internal comparison within the dataset between periods of 'full lockdown' and essentially normal care.

For each patient, a median average score whilst waiting for surgery and the number of weeks in full lockdown were calculated and used in analyses. We considered several methods of measuring the overall exposure of each included patient including median average from diagnosis to surgery or censorship, point estimates at the time of diagnosis or decision for surgery (study entry) and 'area under the stringency curve' (sum of stringency scores multiplied by duration of exposure). Whilst the point estimate at the time of

study entry (date of decision for surgery) would minimise any impact of future information bias, whereby patients may be more likely to be exposed to several lockdown states therefore demonstrate a central tendency (i.e., classified as moderate lockdown overall) we felt that this would misrepresent the complex and dynamic nature of lockdowns, and risk underestimating or overestimating patients' overall exposure. Supporting this decision, we did not see a central tendency in the distribution of calculated median. Balancing the risks and benefits of each method of processing the Oxford COVID-19 government response index we took a pragmatic decision to adopt the median average score for all included analyses.

Appendix E. Challenges with use of SARS-CoV-2 case notification rates

Accurate estimation of a country's SARS-CoV-2 burden is challenging. For example, studies from Zambia and India using post-mortem records and population level sampling have demonstrated a significant underestimation (100-times and higher) of SARS-CoV-2 infection rates and subsequent COVID-related deaths (2, 3). Cross-reactivity with other pathogens endemic in Sub-Saharan Africa has also been reported. Therefore, case rates were used for exploratory analyses only, and stratified by World Bank income tertile. Data on SARS-CoV-2 rates were extracted from the World Health Organisation, European Centre for Disease Control, US Centre for Disease Control and specific national registries via the Our World in Data portal (4). Case notification rates for SARS-CoV-2 reflect the ability of health systems to identify exposed patients, perform accurate tests, and report these to international registries.

Appendix F. Patient level variable descriptions and definitions

Patient level variables included age, sex, American Society of Anaesthesiologists grade, Eastern Cooperative Oncology Group (ECOG) performance status, smoking status, pre-existing respiratory condition, and Revised Cardiac Risk Index (RCRI). To account for different tumour grading and staging systems across the included cancer types, disease status was classified at the time of decision for surgery as early stage (organ confined, non-nodal, non-metastatic, fully resectable) or advanced stage (growth beyond organ, nodal, metastatic operated with curative intent). For analyses of surgical outcomes, grade of surgery was categorised based on the Clinical Coding & Schedule Development Group as either Minor (minor/intermediate) or Major (major/complex major) (5)

Appendix G. Estimation of treatment intervals

In order to estimate the impact of lockdown of treatment delays, the relationship between lockdowns and the interval from diagnosis to surgery was explored. The date of diagnosis was defined pragmatically as the date when diagnostic imaging, laboratory samples, multidisciplinary team discussion, or an outpatient clinic diagnosis was made (whichever was earliest). The interval from date of diagnosis to the date of surgery was calculated in whole weeks. Accepting that there are likely to be significant differences in the 'normal' interval from diagnosis to surgery across different health systems, a 'delay' from diagnosis to surgery was not specifically defined. Several different interval groups were defined pragmatically in 4-week epochs according to describe differences between intervals from diagnosis to surgery and surgical quality. The association between lockdowns and interval from diagnosis to surgery was primarily explored in patients with neoadjuvant therapy (i.e. that went 'straight to surgery').

In secondary exploration, the point of 'system friction' was also reported to compare differences in intervals from diagnosis to decision for surgery, and from decision to operation. Date of decision for surgery was again defined pragmatically as the date of multidisciplinary team discussion, or surgeon's decision to book the patient for an operation.

Appendix H. Classification of reasons for non-operation

Reflecting the complexity of surgical decision making during the pandemic, more than one reason could be selected for non-operation for any single patient. One patient therefore could have both COVID-19 related and not COVID-related reason(s) selected. Where it was unclear whether a reason was directly or indirectly COVID-related (for example, disease progression leading to change in treatment plan) this was attributed as a non-COVID-19 related reason. In practice, it is complex to summarise the exact processes underpinning reasons for treatment delay in this complex multi-specialty and multi-country dataset. These reasons are provided to illustrate the common themes in the data and explore: (1) to what extent cancellation and delay could have been expected as part of ‘normal’ (pre-pandemic) practice; (2) estimate harms incurred to patients as a result of delay or cancellation of surgery due to COVID-related and unrelated causes.

Appendix I. Definitions of secondary outcomes for operated patients

The full protocol definitions of each included secondary outcome were:

- Resection margin status: R0: No microscopic or macroscopic disease, R1: Microscopic disease at the margin, R2: Macroscopic disease at the margin, Pathology unavailable: No histopathological analysis performed or reported, Missing: Missing data).
- Resectable disease at the time of surgery (resectable/unresectable). Unresectable disease was defined by the operating surgeon as surgery performed with a palliative intent (i.e., for symptomatic management, non-curative only) or an abandoned procedure due to concerns around resectability.
- Pre-operative cancer-related complication requiring emergency surgery e.g., obstructed bowel, bleeding at the tumour site. Emergency surgery was defined as an unplanned admission requiring surgery within hours of decision to operate.
- 30-day postoperative SARS-CoV-2 infection rate, confirmed by RT-qPCR testing of a nasopharyngeal swab, or an indicative CT thorax or clinical diagnosis of symptomatic COVID-19 in patients for whom swab testing was unavailable (6, 7).
- 30-day postoperative mortality rate (8-10).
- New detection of metastatic disease up to a maximum of 30-days after surgery. Metastatic disease was defined upon postoperative histological staging, or upon restaging radiological examination where this was performed. Data on detection of new metastatic disease was not collected for liver, pancreatic, breast and gynaecological cancers, therefore rates of detection of new metastatic disease removed these patients from the denominator of estimates of proportions.

Appendix J. Full statistical methodology

No pre-specified sample size calculation was performed. Missing data were included in flowcharts and summary tables, but excluded from the models. We pre-planned to conduct multiple imputation by chained equations if the level of missingness for variables included in the model was greater than 5%. Non-parametric data were summarised with medians and interquartile ranges and differences between groups were tested using the Mann-Whitney U test. Parametric data were summarised with mean average and standard deviation. Differences between groups were explored using two-tailed Student's t-test (two comparator groups) or one-way Analysis of Variance (ANOVA, three or more comparator groups) The $\chi 2$ test was used for categorical data. Cox proportional hazards regression modelling was used to explore association between lockdowns and the primary outcome, presented as adjusted hazard ratios (HR) and 95% confidence intervals. Operation was included as the outcome event, and no censoring was performed for death or progression to unresectable disease to deal with competing risks, given individuals had the same follow-up time (i.e., describing sub-distribution rather than cause-specific hazards). The proportional hazards (PH) assumption was checked using the Schoenfeld individual test and graphical diagnostics based on the scaled Schoenfeld residuals. The proportional hazard assumption was accepted if a non-significant relationship was detected between residuals and time. Clinically plausible health-system, patient, and disease-related factors were selected *a priori* for inclusion in adjusted analyses. Testing for non-linear relationship with the outcome variable was performed for continuous variables by including a penalised spline on the exposure, and plotting a spline term. Where significant non-linear relationships were demonstrated, variables were categorised before inclusion in the model. An alpha level was set at 0.05 (5%) for interpretation of statistical significance.

Appendix K. Further discussion of study topics

Protecting elective surgery pathways

The demand on critical care services during COVID-19 has been unprecedented. Protecting a small proportion of dedicated critical care beds, even when community SARS-CoV-2 incidence is high, will support vulnerable patients and those with advanced disease to undergo the cancer surgery they require. Newer ways of working, including dedicated postoperative units that can provide adequate support for several surgical patients with lower staffing demands, may be necessary (7). These may need to be away from acute sites that may be subject to COVID-19 surges.

Relationship between COVID-19, lockdowns and non-operation

Whilst all patients had a stated reasons for non-operation related to COVID-19, only a proportion of this were seemingly directly attributable to lockdown measures (for example, patients being unable to travel to hospital during periods with travel restrictions). We hypothesise that country-level stringency measures have a direct impact on hospital procedures and planning through lockdown-related hospital/institutional policies i.e., that health systems change to reflect stringent government policies on containment and movement restriction. This is corroborated by a sensitivity analysis which demonstrated that full and moderate lockdowns independently increased the likelihood of non-operation after adjustment for local SARS-CoV-2 case notification rates. This has important policy implications. Whilst the collateral impact of COVID-19 on other health conditions has been widely discussed, there is little published primary data (i.e., not modelled) that provides information about the direct effects of lockdowns on non-communicable disease (11). These data provide important insight for governments when balancing decisions about whether to extend, increase or decrease the stringency of lockdowns, and the broader societal consequences.

Perspectives for policy during future waves

Resilience of elective cancer surgery remains low across all settings (12). Stepping back up to a full capacity service requires advanced planning to cope with future predicted demand. The added complexities of potential future lockdowns mean that expenditure on protected elective capacity for cancer surgery should be considered now by policy makers at national levels. Future lockdowns under current conditions

will worsen outcomes for patients needing cancer surgery against a background of mounting backlogs and delays in many countries.

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